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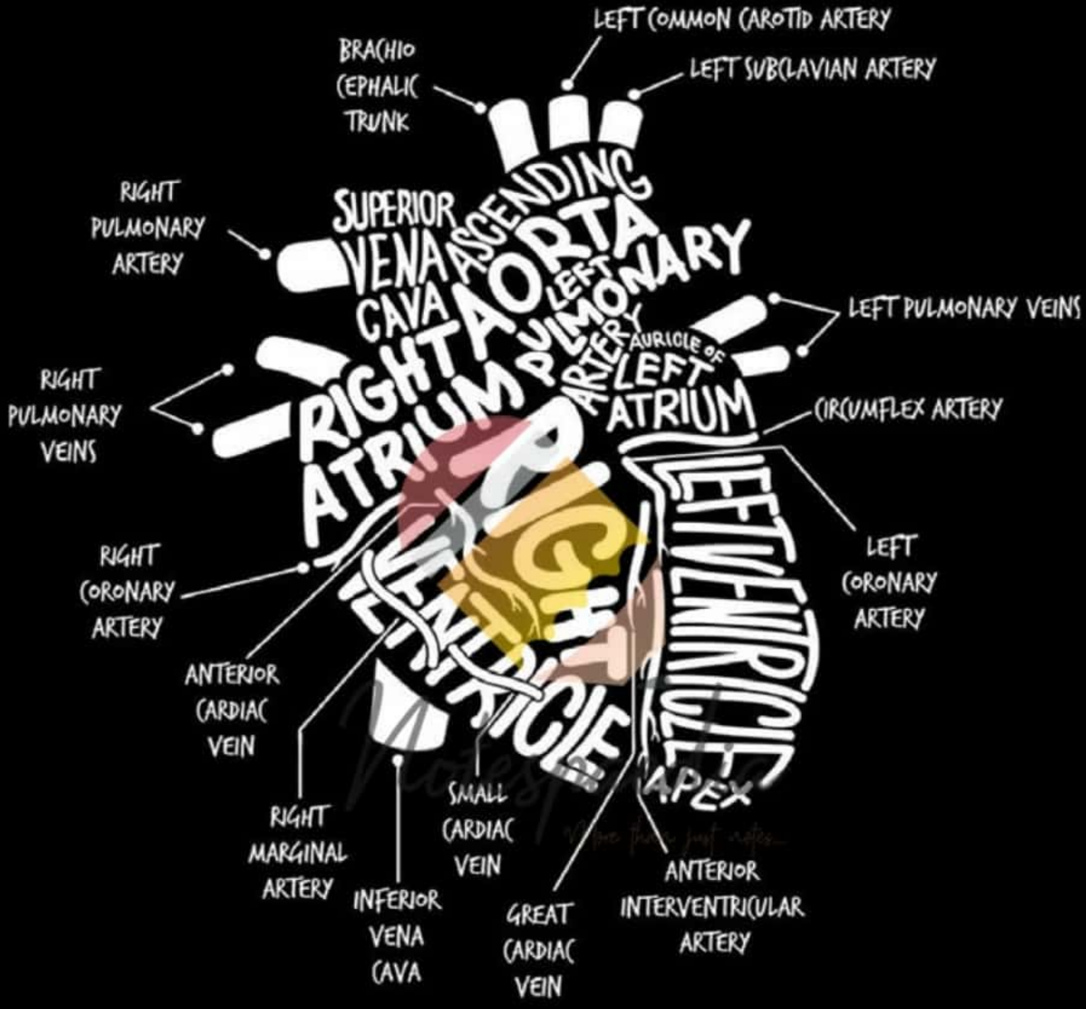
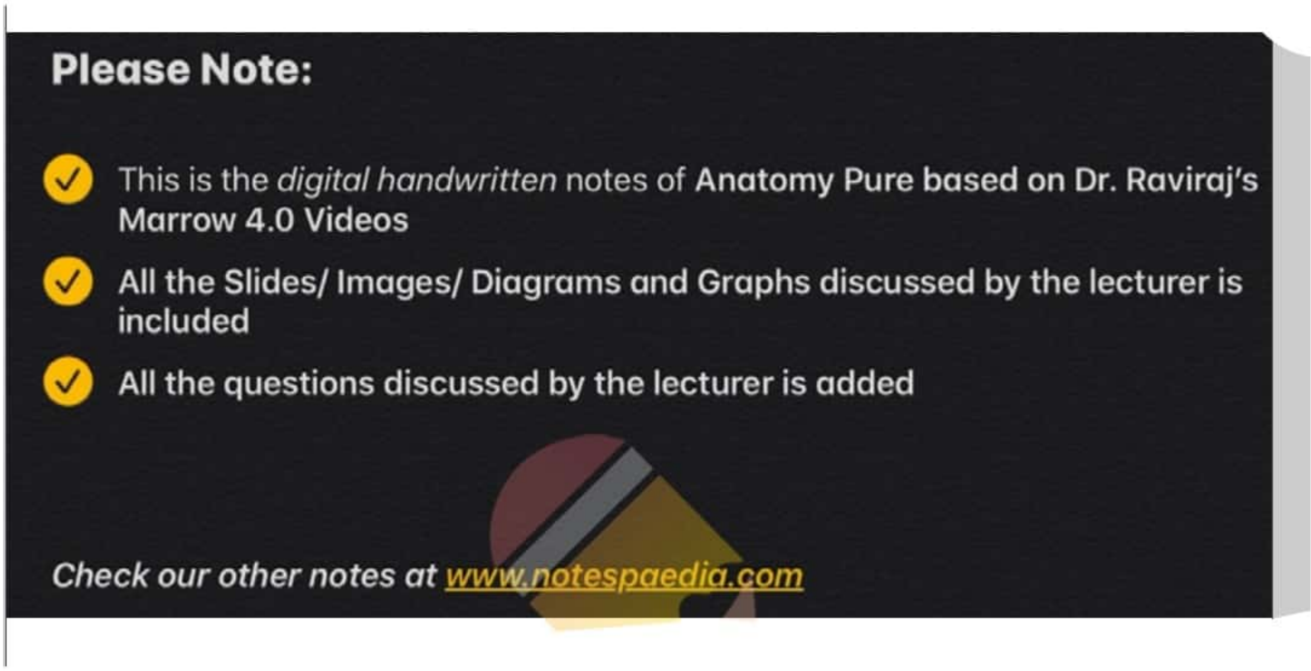
ANATOMY PURE

Based on Marrow 4.0

Embryology and Histology



More than just notes



Please Note:

- ✓ This is the *digital handwritten* notes of **Anatomy Pure based on Dr. Raviraj's Marrow 4.0 Videos**
- ✓ **All the Slides/ Images/ Diagrams and Graphs discussed by the lecturer is included**
- ✓ **All the questions discussed by the lecturer is added**

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GAMETOGENESIS

General embryology:

i) Pre embryonic period - 0-2 weeks
ii) Embryonic period - 3-8th week
iii) Fetal Period - 9 week to birth

Gametogenesis introduction:

Primordial germ cells (PGC):

Produced by epithelial cells - 2nd week

↓

migrate to endodermal wall of yolk sac - 4th week

Applied anatomy:

Primordial germ cell $\xrightarrow[\text{migrate to}]{\text{abnormally}}$ Head and Neck region ⇓ Craniopharngeal teratoma

Primordial germ cell $\xrightarrow[\text{migrate to}]{\text{abnormally}}$ Sacrococcygeal region ⇓ Sacrococcygeal teratoma

Note:

Sacrococcygeal teratoma due to 2 reasions Q 2018 June DNB

i) Abnormal migration of PGC
ii) Persistence of primitive streak

Terminologies:

1. Totipotent cell:
   - Ability to form entire embryo & extra-embryonic tissue
   - up to 8 cell stage
2. pleuripotent cell:
   - Abity to form all germ layers

   eg. PGC
3. multipotent cell:
   - Ability to form more than 1 Category of cell

   eg. Hematopoietic stem cell
4. Oligopotent cell:
   - Ability to form 1 Category of cell

   eg. Vasular stem cell
5. Unipotent cell: Forms only 1 type of cell eg. Liver cells

CHAPTER 14 : UROGENITAL SYSTEM 321

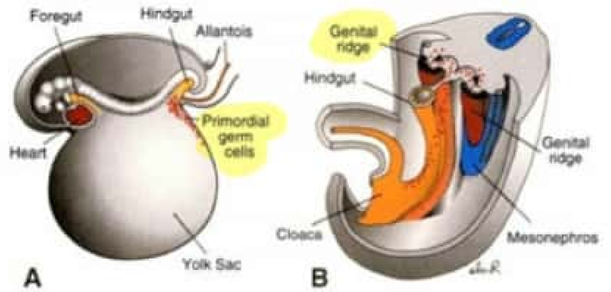
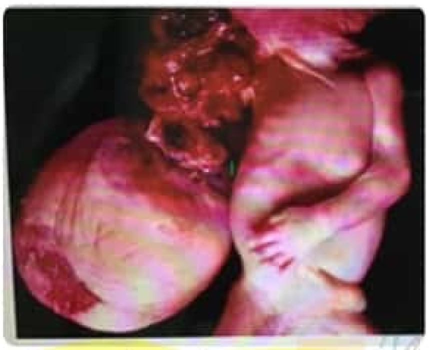


Figure 14.18. **A.** A 3-week-old embryo showing the primordial germ cells in the wall of the yolk sac close to the attachment of the allantois. **B.** Migrational path of the primordial germ cells along the wall of the hindgut and the dorsal mesentery into the genital ridge.



Craniopharyngeal

Mitosis	Meiosis [PGI-2018]
i) equavational divition 46 → 46, 46	i) Reduction divition 46 → 23, 23 [Haploid cell]
ii) occurs in Body cells	ii) occurs in germ cells
iii) crossing over - does not take place ∴ daughter cells resemble parent cells	iii) crossing over - does take place ∴ daughter cells do not resemble parent cells
	iv) meiosis take place twice in gametogenesis - meiosis I & II
	v) phases of meiosis : prophase, metaphase, Anaphase Telophase -stages in prophase leptotene zygotene Pachytene Diplotene (resting phase)

Oogenesis:

PGC in ovary [5th week]

↓

Oogonium

[By 3rd month, All PGC → Oogonium]

↓

Primary oocyte

[By 5-7th month, All Oogonium → 1° oocyte]

↓ meiosis - I (prophase)

Diplotene phase

(until puberty)

↓ After Puberty

1° oocyte

↓

2° oocyte + 1st polar body

[∵ unequal division of cytoplasm]

(Polar body - a cell without cytoplasm)

↓ Meiosis - II

Completes prophase & metaphase

↓

metaphase arrest - 24 hrs

Sperm ⊕ → Complete meosis-II → ovum & IInd polar body

Sperm ⊖ → corpus luteum

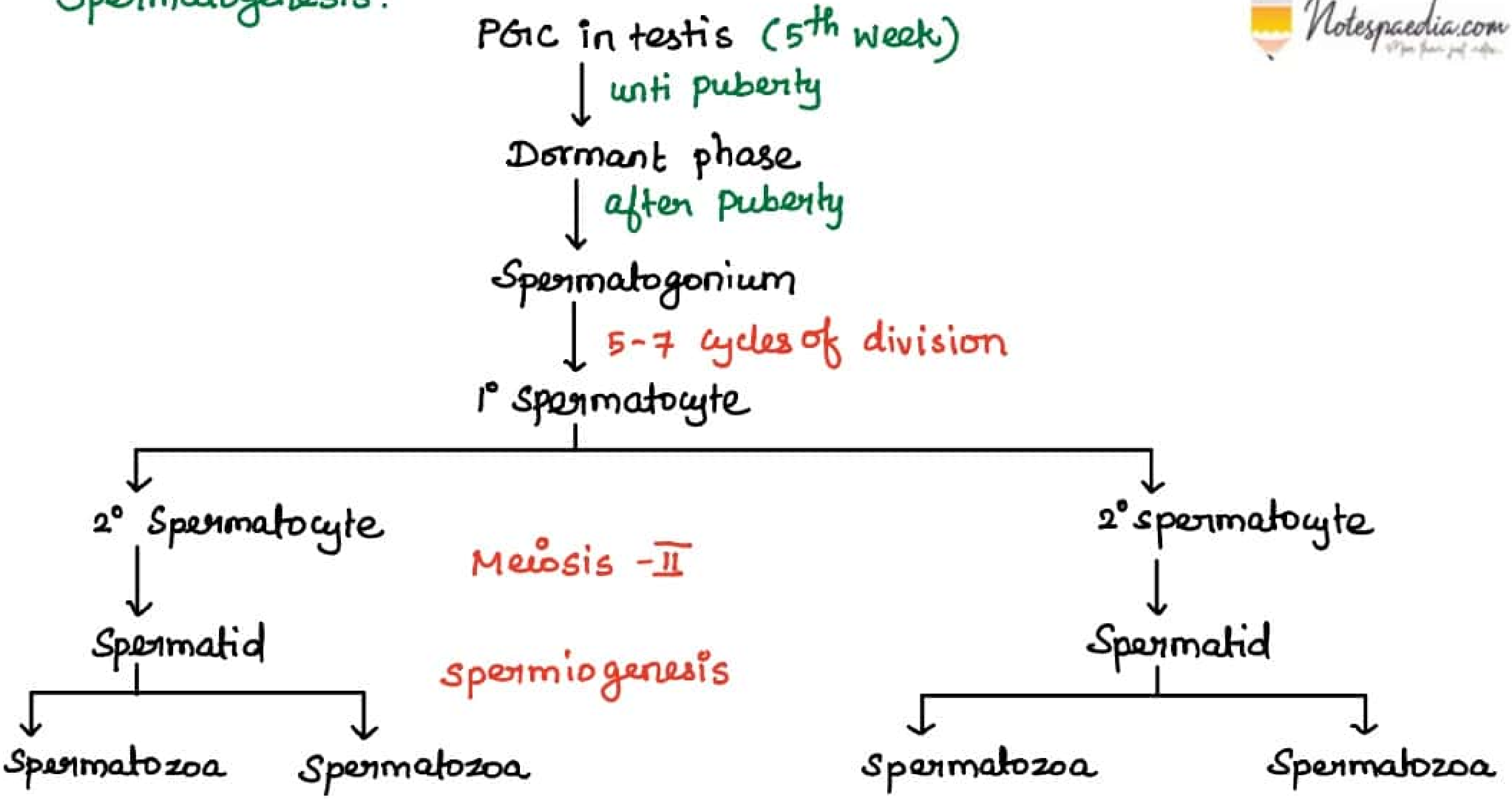
- persists for 14 days
- Shrinks 3-4 days prior to menstrual phase

corpus albicans

(white scar)

↑

Spermatogenesis:



Note:

No polar body formation in males (Spermatogenesis)

Spermiogenesis - Arrangement of organelles [Formation of tail, acrosomal cap, shedding of excess cytoplasm]

one 1° spermatocyte → forms 4 Spermatozoa

1 spermatogonium → 64 - 512 spermatozoa

Sequence of structures formed in Spermatogenesis: [2019 - May AIIMS]

PGC
↓
Spermatogonium
↓
Spermatocyte
↓
Spermatid
↓
Spermatozoa

Spermatogenesis Vs Oogenesis

	Spermatogenesis	Oogenesis
1. onset	After puberty	Intrauterine life
2. Polar body	⊖	⊕
3. Gonads	one 1° spermatocyte ↓ 4 Spermatozoa.	one 1° oocyte ↓ 1 ovum

One liners in gametogenesis:

1. Spermatogenesis completes in 74 days (recent update) > 64 days > 60 days

2. LH (luteinizing hormone) surge - 36 hrs before ovulation
   LH peak - 12 hours before ovulation

3. most fertile period - 3 days
   2 days before ovulation + 1 day after ovulation

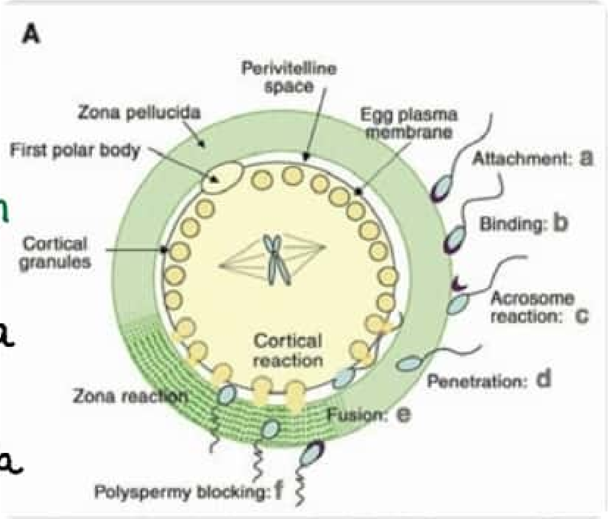
4. In male :
   - Meiosis - Occurs in Seminiferous tubules
   - Sperm maturation & motility - occurs in epididymis
   - Capacitation of sperm - female genital tract
     - conditioning of sperms
     - Lasts for 7 hrs

Fertilization

Fertilization - 1st week of development:

Fertilization → Occurs in the ampulla of follopian tube

Zona pellucida → A tough membrane which prevents Polyspermy, implantation



a - Attachment

Sperm attaches to zona pellucida

b - binding

↓

Sperm binds to zona pellucida

c - Acrosomal reaction

↓

Release of acrosomal enzymes ⇒ contain's
- Acrosin
- Acid phosphatase
- Hyaluronidase

d - penetration

↓

Sperm Penetrates zona pellucida

↓

cortical reaction

[cortical granules → Release Secretion/Enzymes]

↓

Zona reaction

Zona reaction:

zona → Prevents Polyspermy
[By altering its permeability]

Implantation :

Male pronucleus fuses with female pronucleus
↓
zygote
↓
2 cell stage
↓
4 cell stage
↓
8 cell stage
↓
Compaction
[loosely arranged blastomeres are held together by tight junctions]
↓
Differentiation
8 cells → 16 cell stage [morula]
↓
Cavitation [formation of Blastocyst]
↓
Disappearance of zona Pellucida, hatching of Blastocyst
⇓
Implantation

Time and Site of events:

- Zygote → within 12-24 hours of ovulation
- 2 cell stage → 24 hours after fertilization
- Morula → 3rd day after fertilization
  [8 to 16 cell stage]
- Advanced morula → 4th day after fertilization
  [32 cell stage]

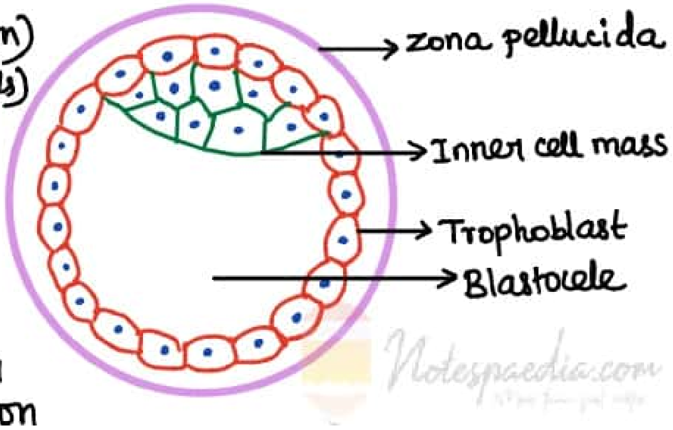
Note :
Advanced morula/32 cell stage → Enters uterine cavity

- Blastocyst → 4 ½ days after fertilization

Total of 58 cells (at the time of formation)
- outer cell mass (53 cells) - Inner cell mass (5 cells)

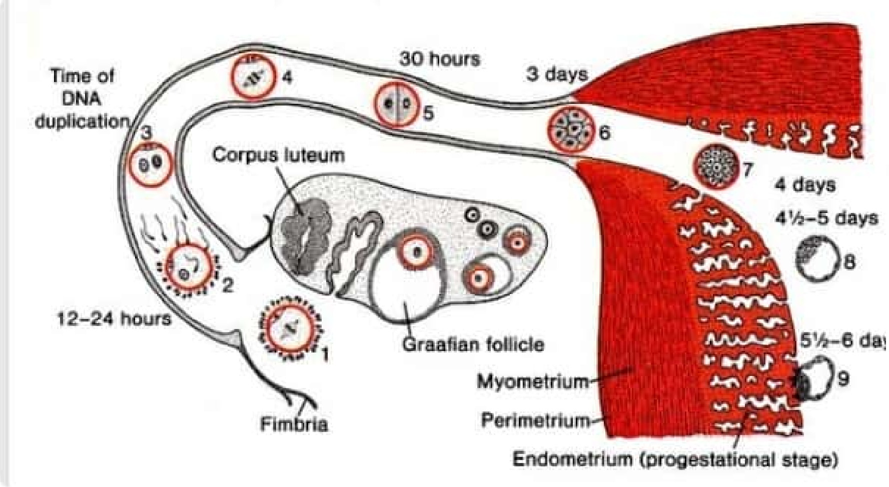
↓ Trophoblast [contributes to the formation of placenta]

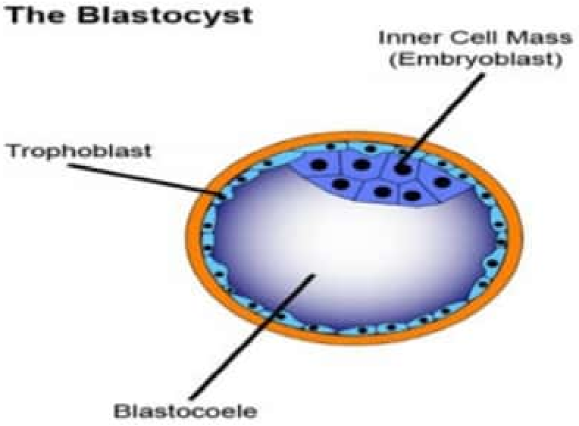
↓ Embryoblast ↓ Embryo proper



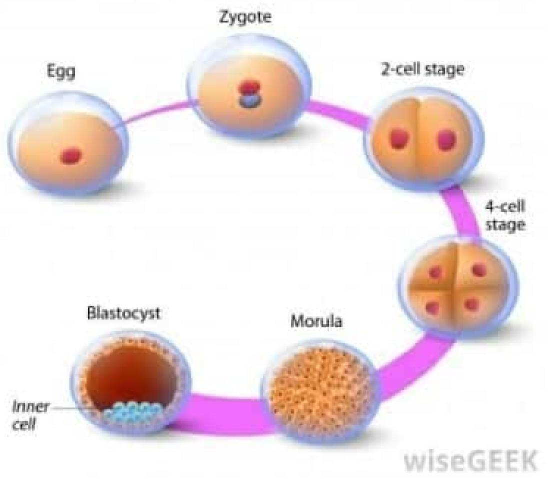
- Zona pellucida disappears → 5th day after fertilization

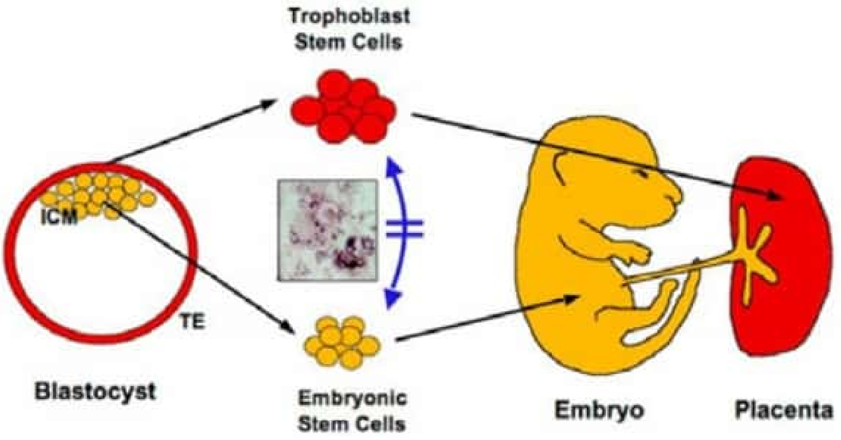
- Implantation → 6th - 7th day after fertilization
  (In functional layer of endometrium)
- At the time of implantation → 100 - 250 cells





DEVELOPMENT OF THE EMBRYO





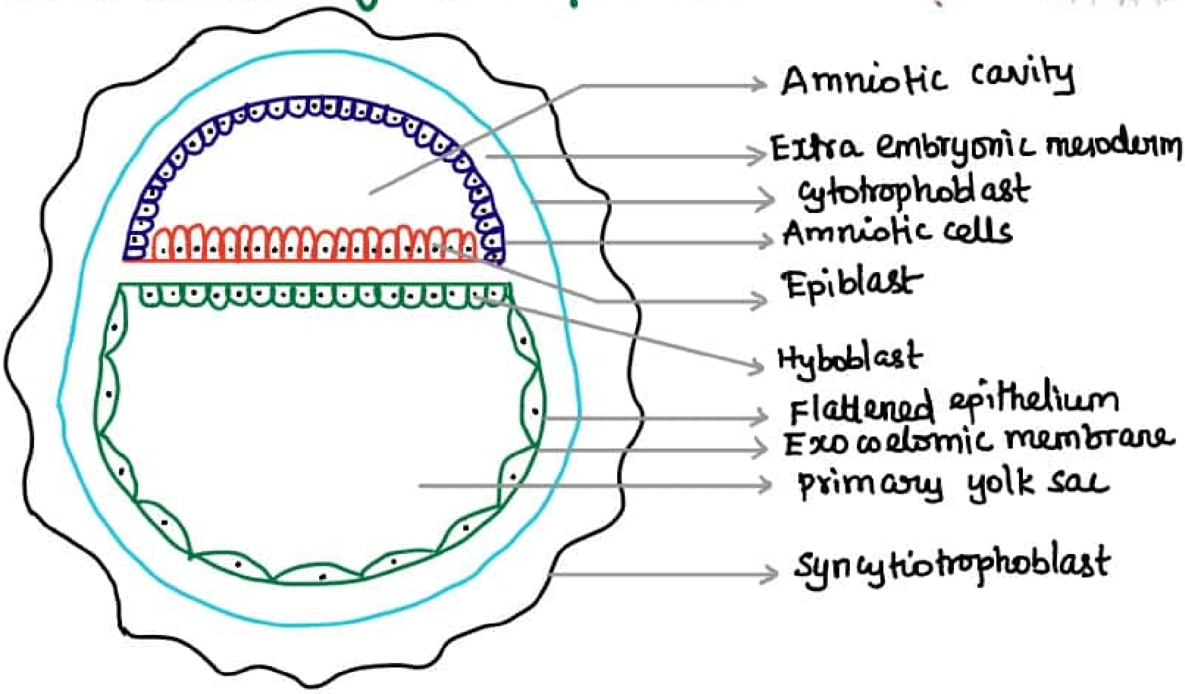
Applied anatomy:

- Ectopic pregnancy
  Implantation in Fallopian tube (most common site)
  Sign & symptoms → similar to appendicitis
  Treatment - termination of pregnancy

- Serum HCG : low (not as much as in pregnancy)
  ↓
  HCG : initially Secreted by Syncytiotrophoblast

In ectopic tubal pregnancy - Syncytiotrophoblast not well developed

Second week of development



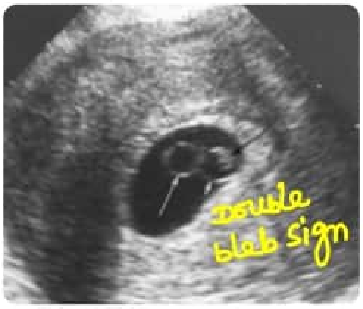
Inner cell mass

↓ Epibast columnar cells on dorsal aspect
↓
Forms amnion and encloses cavity lined by amniogenic cells

↓ Hyboblast cuboidal cells on the ventral aspect
↓
Forms exocoelomic membrane and enclose primary yolksac lined by flattened epithelium

USG in 2nd week of development :

"Double bled sign" - 2 bubbles [1° yolk sac & amniotic cavity]



Outer cell mass (trophoblast)
on day 8

↓ Cytotrophoblast

↓ Syncytiotrophoblast

Extra embryonic mesoderm:
present between inner cell mass and cytotrophoblast
Formed by 1° yolk sac > epiblast > Hypoblast

Syncytiotrophoblast:
Syncytiotrophoblast secrete HCG → secrete progesterone to maintain pregnancy

Assay of HCG:
8th day : maternal blood
9-10th day : maternal urine
[on the first day of missed Period]

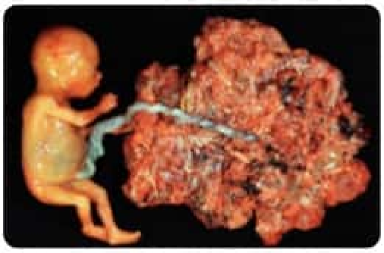
Low HCG:
i) Ectopic pregnancy
ii) Spontaneous abortion

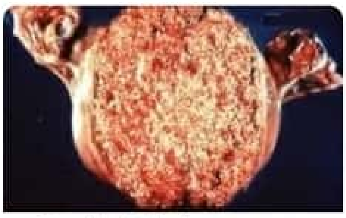
Elevated HCG:
i) Multiple pregnancy
ii) molar pregnancy
Abnormal placenta with proliferation of chorionic villi

Types:

Partial mole - some fetal parts ⊕

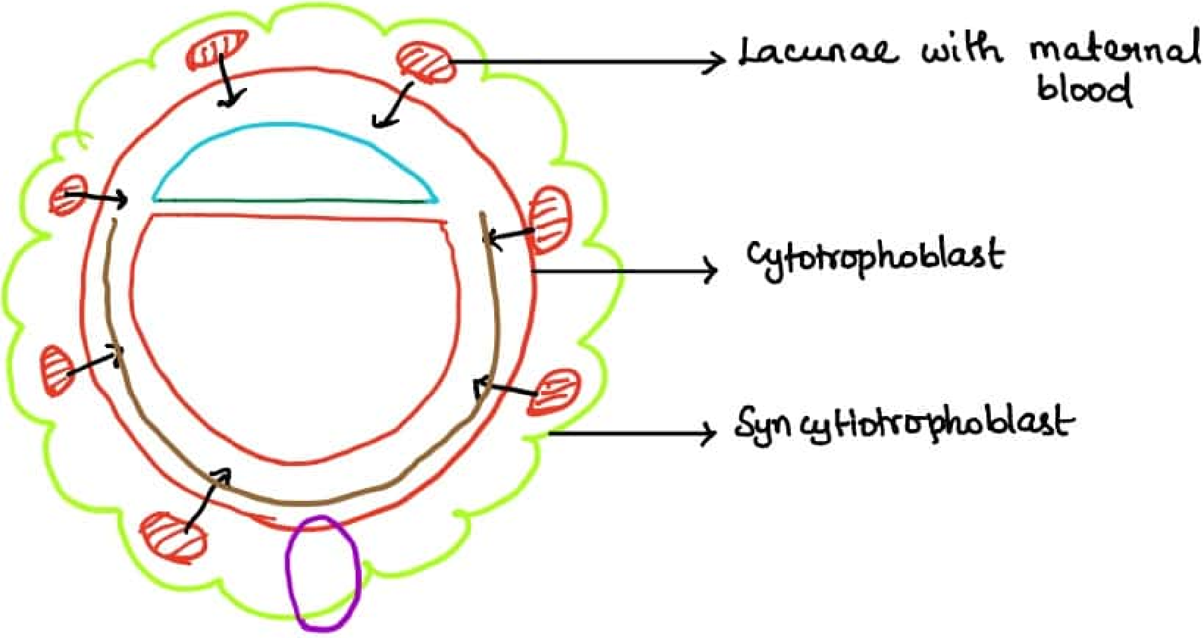
Complete mole - No fetal parts Grape like clusters





Complete Molar Pregnancy

Formation of chorion - Primary chorionic Villi:



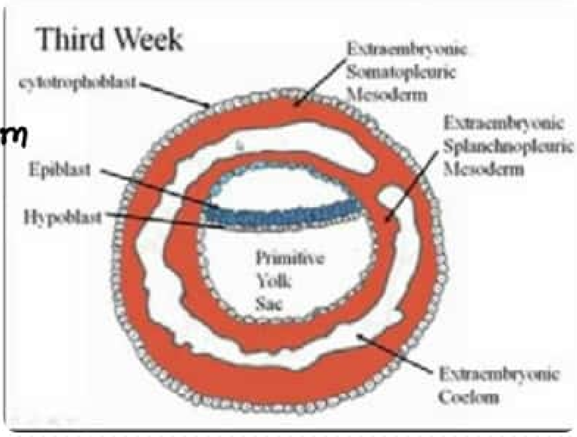
- 1° chorionic villi
  - cyto + Syncytotrophoblast
  - Formed before day 12
- Syncytiotrophoblast

Invades the endometrium + Endometrial vessels
↓
Formation of lacunae filled with maternal blood
↓
maternal blood diffuse into inner cell mass
↓
utero-placental circulation established
[by day - 15]

1st System to develop : Cardiovascular System
Formation of heart tubes

Fetoplacental circulation established.
[Day 17 > Day 22] NEET 2018

Formation of Secondary Chorionic Villi :



Cavity in Extra embryonic mesoderm → divides mesoderm into parietal layer and Splanchnopleuric mesoderm

Amniotic Cavity lininig:
Externally → parietal layer of Extraembryonic mesoderm
Internally → Amniogenic cells.

2° chorionic villi :
- Somatic / Parietal Extraembryonic mesoderm + Cytotrophoblast + Syncytotrophoblast
- Formed on day 12

Note: Undivided Part of Extraembryonic mesoderm
→ Forms connecting stalk
↓
Umbilicus

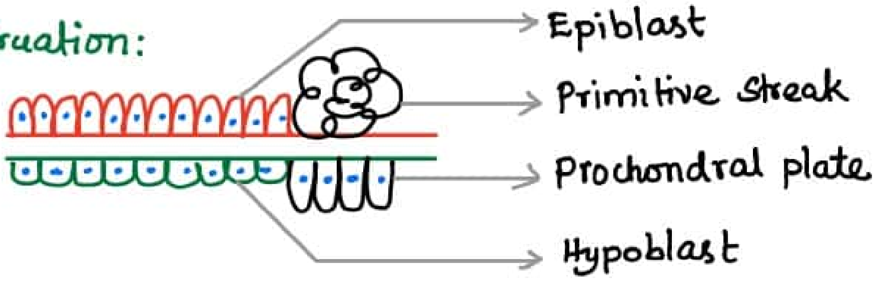
Summary of development in 2nd week:

a) 2 layers of inner cell mass (ICM) : Epiblast
Hypoblast
b) 2 layers of outer cell mass : Cytotrophoblast
Syncytiotrophoblast
c) 2 layers of Extraembryonic mesoderm formed :
Splanchnopleuric and Parietal layer
d) 2 villi : 1° and 2° chorionic villi
e) Amnion and chorion formed

Third week and placental development

i) Gastruation - Formation of germ layer
ii) Neurulation - Formation of neural tube
- Gastruation & Neurulation occurs in 3rd week

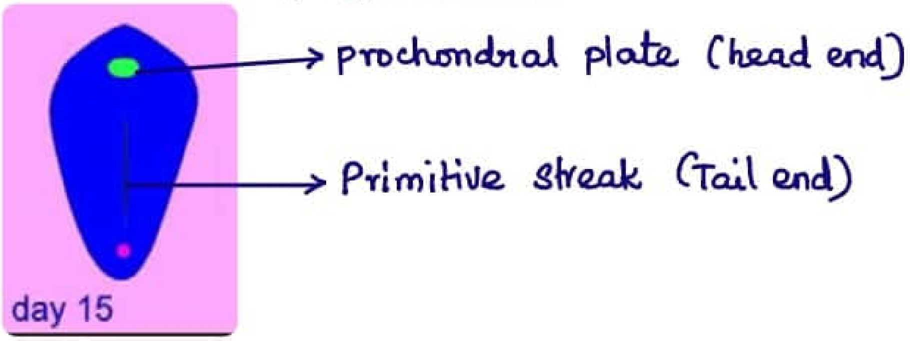
Gastruation:



- Germ layer formation - Cranio - caudal sequence
  - i) Hypoblast - cuboidal cells
  - ii) Epiblast - Columnar cells
  - iii) Prochondral plate - columnar cells of hypoblast (Cuboidal → columnar)
    - Prochondral plate
      ↓
      Bucopharyngeal membrane
      ↓
      Oral cavity
    - Prochondral plate is formed in the head end of the embryo

iv) Primitive streak:
- Tail end
- Derived from epiblast
- Formation starts at the end of 2nd week / Beginning of 3rd week [14 or 15th day]
- Indicates the starts of gastruation

Day 15:



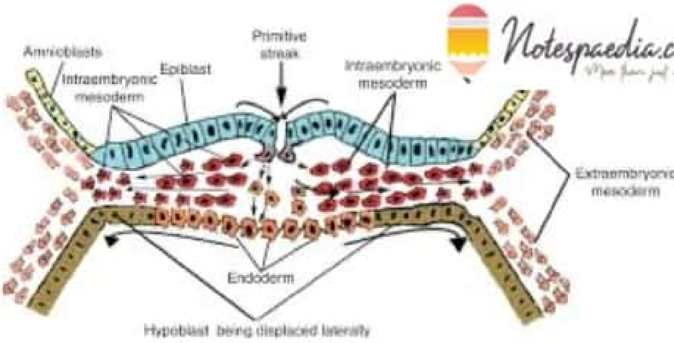
Note: Sacrococcygeal teratoma:
- cause : i) Abnormal migration of PGC (Primordial germ cells)
  ii) Persistence of PS (Primitive streak)

Germ layer development:

Formed in cranio - caudal sequence
i) 1st germ layer to develop → Endoderm [derived from epiblast]
- Endoderm → Replaces hypoblast

ii) 2nd Germ layer to develop →
Intra embryonic mesoderm
(derived from primitive streak)

- Primitive streak → derived from epiblast
- Intra embryonic mesoderm
  → spreads throughout the disc except Prochondrial plate & cloacal membrane



Note:

Prochondral plate & Intraembryonic mesoderm → made of only Ecto and endoderm

iii) 3rd germ layer to develope → Ectoderm

- The remains of epiblast after the formation of Intraembryonic mesoderm

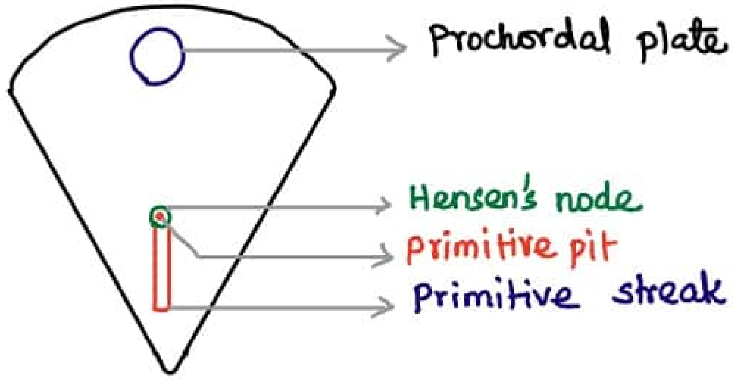
Note:

All the germ layers are derived from Epiblast > Yolksac

iv) 4th germ layer → Neural crest cells (NCC)

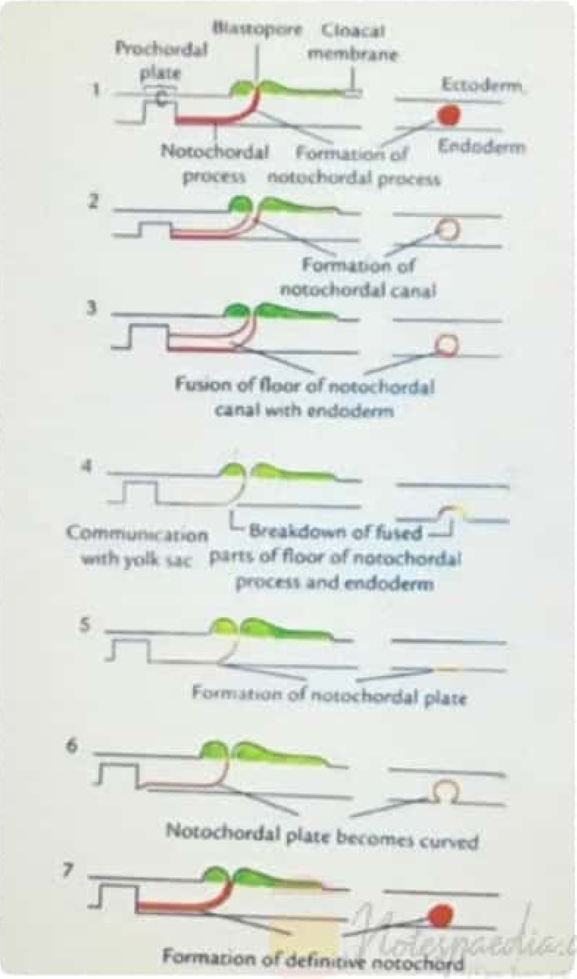
- 2° mesenchyme

Notochord development:



Hensen's Node
↓
proliferation of Hensen's node
↓
Prenotochordal cells
↓ Invaginates
Blastophere / Primitive pit

Hensens Node
↓
primitive pit
↓
Notochordal process
↓
Formation of Notochordal plate
↓
Formation of Notochord


Blastopore
Cloacal membrane
Prochordal plate
1
Ectoderm
Notochordal process
Formation of notochordal process
Endoderm
2
Formation of notochordal canal
3
Fusion of floor of notochordal canal with endoderm
4
Communication with yolk sac
Breakdown of fused parts of floor of notochordal process and endoderm
5
Formation of notochordal plate
6
Notochordal plate becomes curved
7
Formation of definitive notochord

Fate of Notochord:

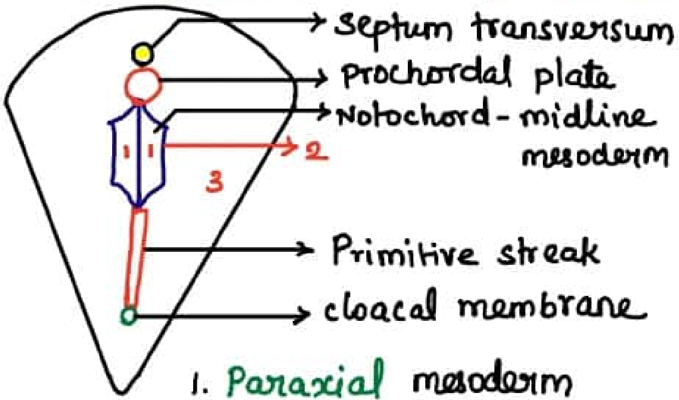
Notochord
↓ disappears
Remnants of notochord

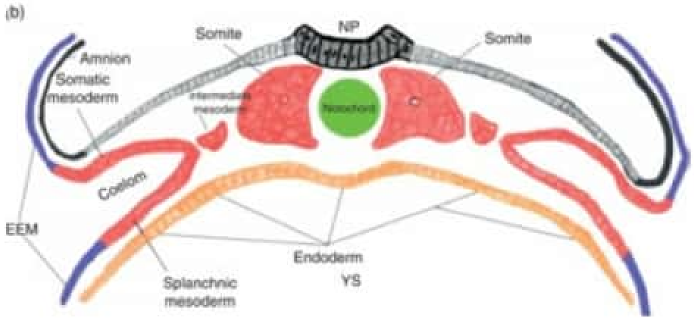
- Nucleus pulposus > Apical ligament of dens

Role of Notochord:

Notochord
↓
Stimulates ectoderm to form neural plate
↓
Neural tube

Intra embryonic mesoderm & Its types:



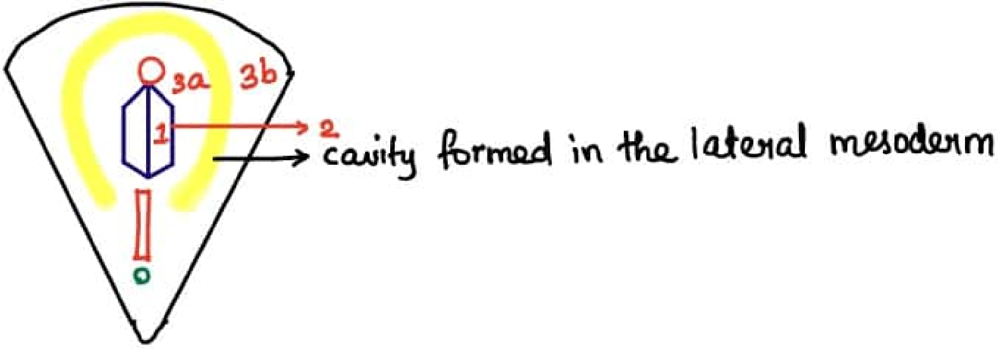


1. Paraxial mesoderm
2. Intermediate mesoderm
3. Lateral mesoderm

Septum Transversum:

undivided part of lateral mesoderm
Cranial to prochondral plate
contributes to formation of -

i) Diaphragm
ii) Liver - connective tissue, Kupffer cells, sinusoids
iii) Fibrous pericardium

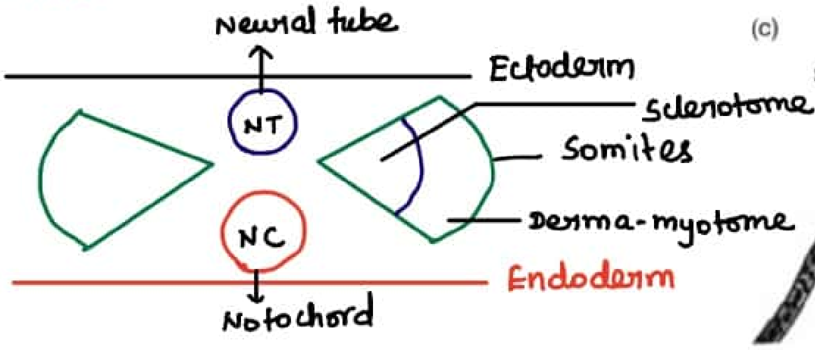


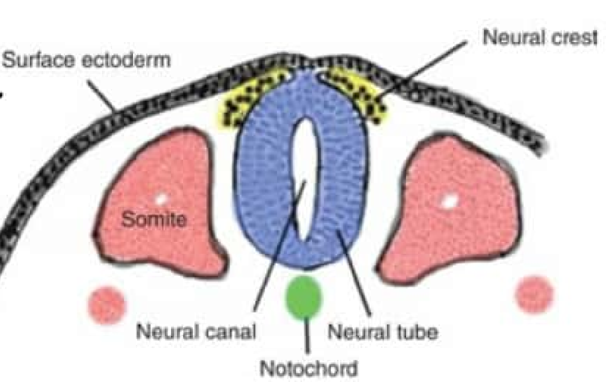
Lateral mesoderm - divides into 3a, 3b due to cavity
1 - Paraxial mesoderm → Forms somites
2 - Intermediate mesoderm → urogenital system
[Kidney, Testis / mesonephric duct,
para mesonephric duct]
3 - Lateral mesoderm → Body cavities [pleural, Pericardial, Peritoneal cavity]
[Cavity]

3a - Splanchnopleuric layer of lateral mesoderm
↓
Forms cardiac & smooth muscles, visceral layer

3b - Somatic layer of lateral mesoderm
↓
- Forms Appentiular skeleton [upper limb (UL) & lower limb (LL) bones]
- Forms Parietal layer

Somites:



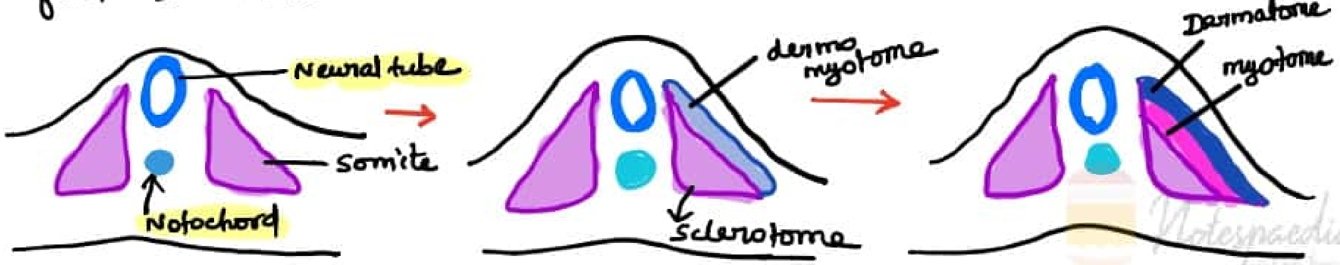


i) 1st Pair of Somites
- Appears in occipital region
- On 20th day

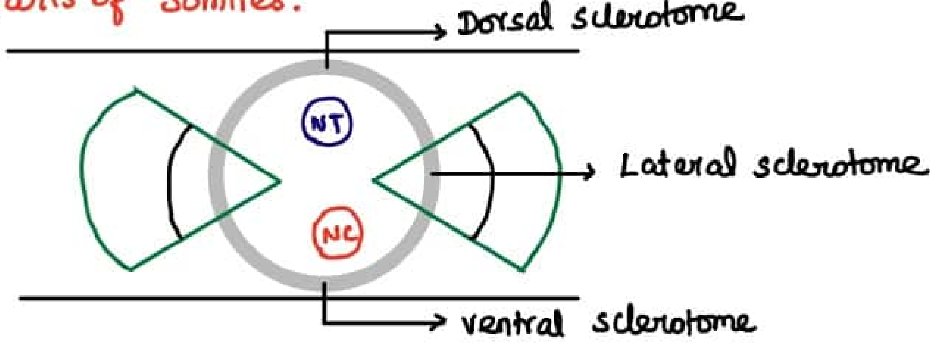
3 pairs are added each day
- 21st day → 4 pairs, 22nd day → 7 pairs ......
- ∴ on 35th day / 5th week → ~45 pairs [42-44 pairs]

ii) Formation of somites:
(1st) occipital
↓
cervical
↓
Thoracic
↓
Lumbar
↓
Sacral
↓
coccygeal

Note:
Some somites in the occipital & coccygeal region - disappear
⇓
∴ 37 pairs of somites [after 5th week]
The number of somites vary upto 5th week, then remain constant after 5th week



Parts of Somites:



1. **Sclerotome:** Surrounds notochord (NC) & Neural tube (NT)

Somites
- Sclerotome
  ⇓
  Axial skeleton
  [Vertebra]
- Dermomyotome

Sclerotome
- Ventral
  ⇓
  Forms body of vertebra
- Lateral
  ⇓
  Vertebral Arch
- Dorsal Sclerotome
  ⇓
  Spine of the Vertebra

Applied anatomy:
i) Hemi vertebra → Failure of fusion of vertebral sclerotome
ii) Hemi bifida anomalies → Failure of fusion of dorsal sclerotome

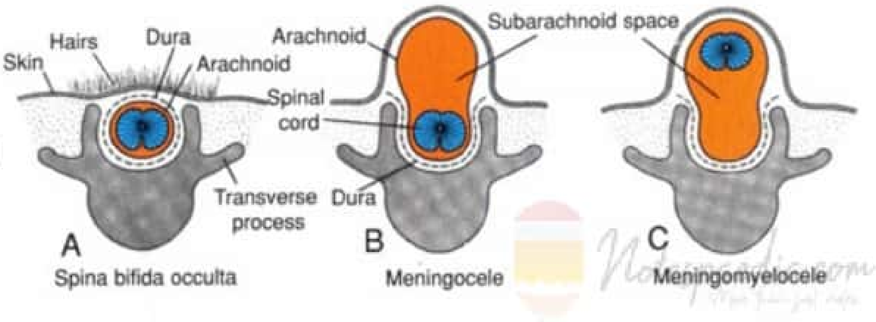
2. **Dermomyotome:**

Dermomyotome
- Dermatome
  ⇓
  Dermis of skin
- Myotome
  ⇓
  Skeletal muscle

Note:
i) UL bones → Derived from somatic layer of lateral mesoderm
ii) UL muscles → Derived from myotome of somites [Paraxial mesoderm]

Spina bifida - anomalies:

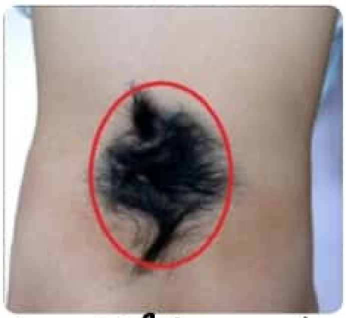
i) Spina Bifida occulta:
- Failure of fusion of dorsal Sclerotome
- Tuft of hair → seen over the defect.

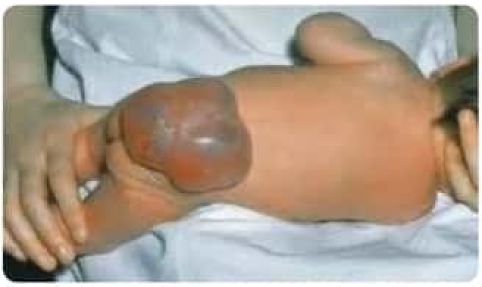


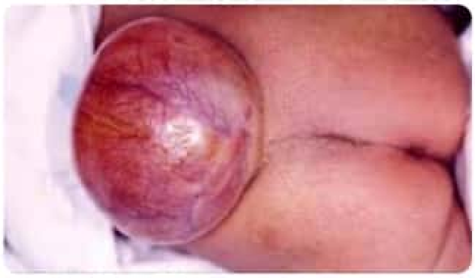
Spina bifida occulta
Meningocele
Meningomyelocele

ii) meningocoele:
- Failure of fusion of dorsal sclerotome
- Protrusion of meninges over the defect

iii) Meningomyelocoele:
- Failure of fusion of dorsal sclerotome
- Protrusion of meninges with spinal cord in it


Spina bifida occulta


Meningocoele


Meningomyelocoele

Development of smooth muscles:

i) Derived from splanchnopleuric layer of lateral mesoderm

Note : a) Smooth muscle over dorsal aorta
⇓
Derived from: Splanchnopleuric layer of lateral mesoderm > paraxial mesoderm

b) Smooth muscles over Iris
⇓
Derived from: Neuroectoderm [May 2019 Jipmer]

c) Smooth muscles over sweat & mammary gland
⇓
Derived from: Surface ectoderm

d) Smooth muscles over pharyngeal arch arteries
⇓
Derived from: Neural crest cells

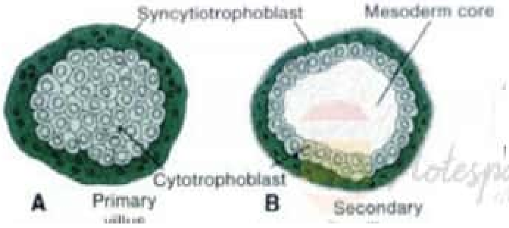
Neurulation & Angiogenesis:

1. Neurulation:
Formation of Neural tube
occurs in the 3rd week

2. Angiogenesis:
Formation of blood vessels
occurs in the 3rd week
Mesodermal layers differentiate → blood vessels

i) Initially splanchnopleuric layer of Extra embryonic mesoderm (EEM)
↓ differentiate
Blood vessels

ii) Later, Smotic layer of EEM
↓ differentiate
Blood vessel (Tertiary villi)



Tertiary villi :

Tertiary villi contains → Blood vessels
+
Somatic layer of EEM
+
Cytotrophoblast
+
Syncytotrophoblast

Forms by the end of 3rd week (21st week)

Angiogenesis - Sequence :

Mesodermal layers (splanchnopleuric, somatopleuric layers of Extra embryonic mesoderm)
↓ differentiates
Blood vessels (Tertiary villi)
↓
Blood vessels formation in intra embryonic mesoderm (IEM)
Anastomosis of blood vessels in the EEM with the IEM

Applied anatomy:

Angioma :
Tumor of the blood vessel (mesodermal layer)

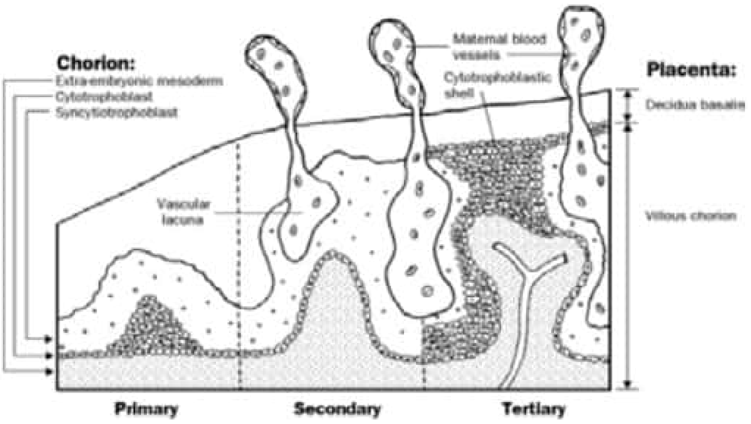
Hematopoiesis:

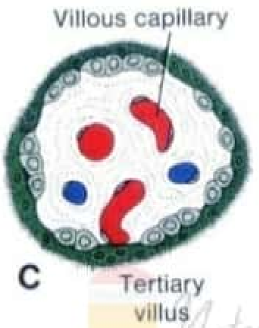
Formation of blood cells
carried out by
- upto 5th week → splanchnopleuric layer of extra embryonic mesoderm
- From 5th week → L - Liver
  T - Thymus
  S - Spleen
  B - Bone marrow

Note:
Liver → Hematopoiesis occurs only upto 7th month

Placental development:

Contributed by 2 components
i) Maternal component - Decidua basalis
ii) Fetal component - chorionic villi [NEET - 2014]





Decidua:

uterine endometrium during pregnancy

i) **Decidua basalis:**

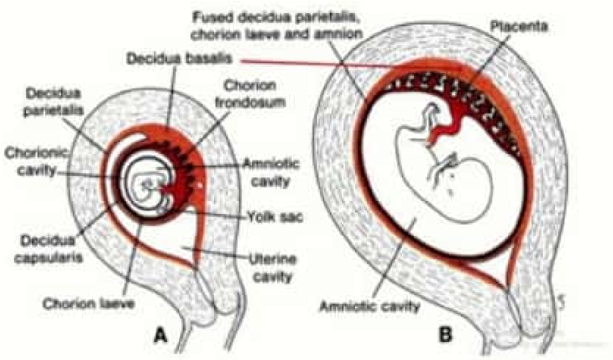
- Between fetus & myometrium of the uterus
- maternal component of placenta

ii) **Decidua capsularis:**

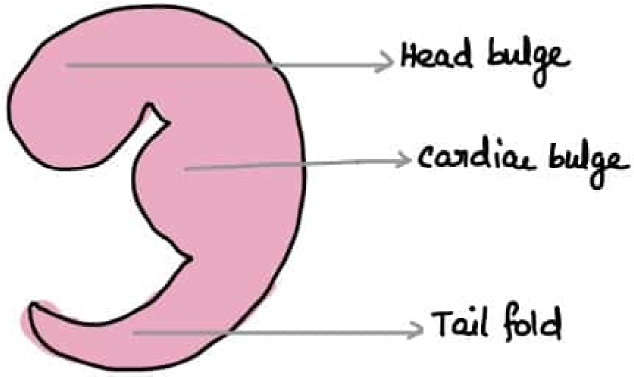
Between fetus & uterine cavity

iii) **Decidua parietalis:**

The rest of decidua



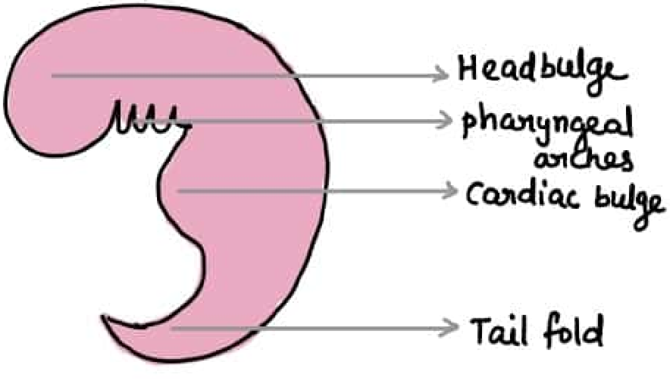
Development of Head and Neck



Neck : Formed by Neural crest cells (NCC)

NCC migrate to future neck region by 4th week
↓
From pharyngeal arches

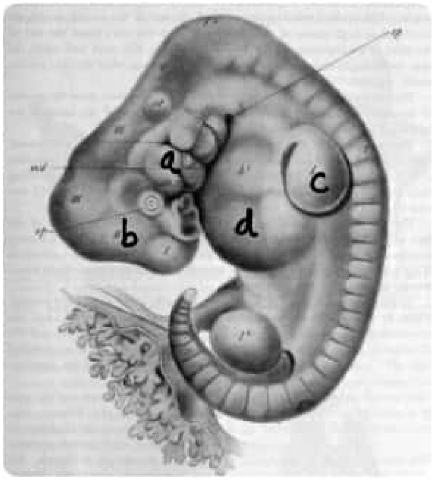
↓



Pharngeal arches

mesenchymal condensation derived from

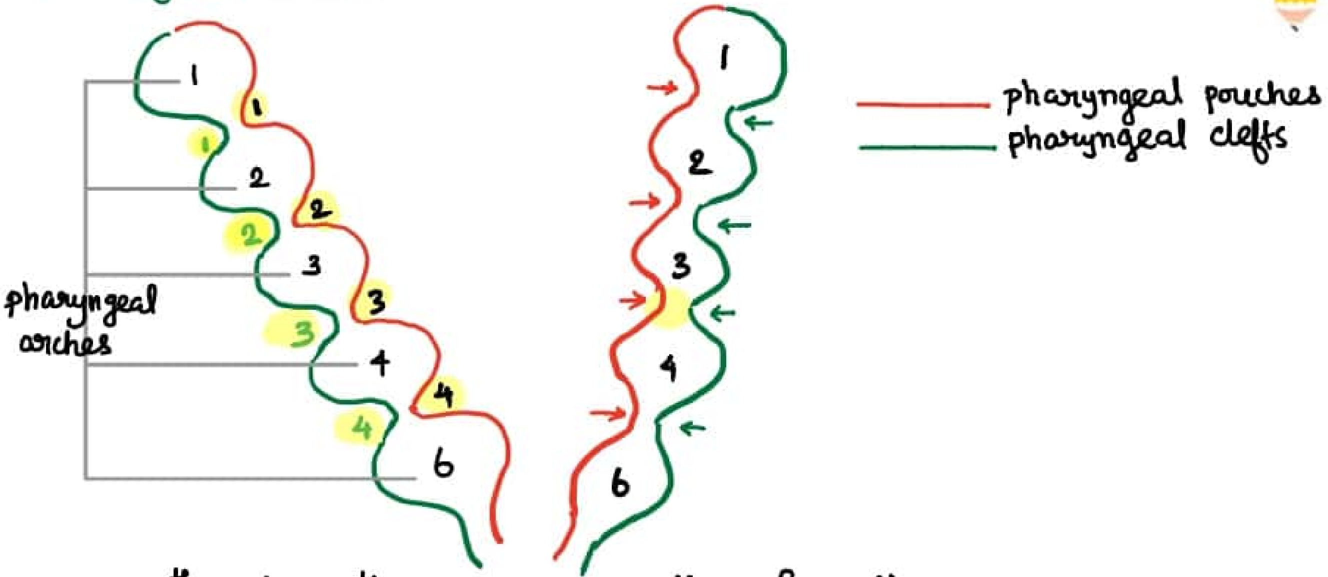
1) Neural crest cells (major)
2) Intra embryonic mesoderm [proximal & lateral plate mesoderm]



a - pharngeal arch
b - Head bulge
c - upper limb bud
d - Cardiac bulge

(AIIMS '17)

Pharngeal arches:



5th arch - disappears soon after formation

Inner endoderm : Forms Pouches (4)

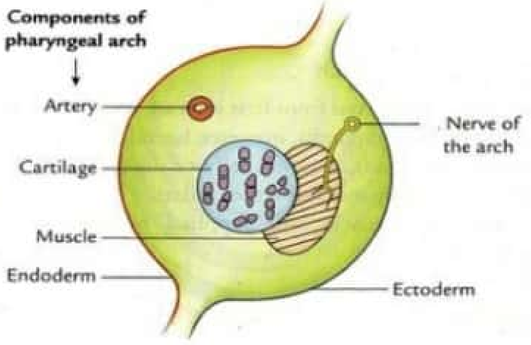
outer ectoderm : Forms clefts (4)

pharyngeal membrane:

point where ectodermal cleft meets
Endodermal pouch
contain's all 3 germ layers
4 in number → 1st pharyngeal membrane persists → Forms tympanic membrane
The remaining membranes disappear

Derivatives of pharyngeal arches:

pharyngeal arch → mesenchymal condensation derived from NCC
+
Mesoderm



Components:

- Cartilage
- Muscles
- Nerves
- pharyngeal arch arteries

Arch	Cartilage	muscle	Nerve	Artery
I arch Mandibular arch	Meckels cartilage - malleus, incus, anterior ligament of malleus, Sphenomandibular ligament, maxilla, mandible, Sphenoid zygomatic & Temporal bones	Muscles of mastication + myelohyoid, Anterior belly of Digastric, Tensor Palatini, Tensor tympani	Mandibular nerve	mandibular artery

II arch Hyoid arch	Richter's cartilage Stapes Styloid Stylohyoid ligament Superior surface of hyoid Small horn of hyoid	muscles of facial expression + posterior belly of digastric Stylohyoid, stapedius	Facial nerve	Stapedial artery
III arch	Greater horn of hyoid + Inferior surface of hyoid	Stylopharyngeus	Glossopharyngeal (IX) nerve	common carotid External carotid & Internal carotid
IV arch	Cartilages of larynx except epiglottis	muscles of pharynx + Palate + cricothyroid	Superior laryngeal nerve	Arch of aorta Right subclavian artery
VI arch		muscles of larynx except cricothyroid	Recurrent laryngeal nerve	Pulmonary artery Ductus arteriosus

Epiglottis : Derived from mesoderm of hypobronchial eminence of IV arch

High yield points:

Muscles of larynx - VI arch
Except cricothyroid - IV arch

Muscles of pharynx - IV arch
Except stylopharyngeus - III arch

Muscles of palate - IV arch
Except Tensor Palatini - I arch

Anterior belly of digastric - I arch [NEET-19]
posterior belly of digastric - II arch

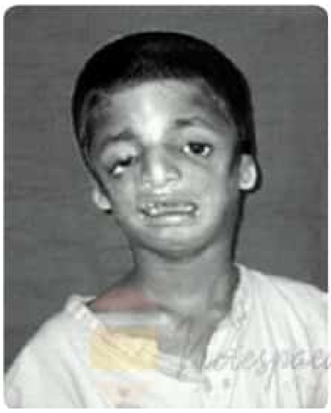
Middle ear muscles:
Tensor tympani - I arch
Stapedius - II arch

Treacher collins and pierre robinson Syndrome:

Treacher collin syndrome:

Failure of differentiation of I^st arch

Features:
- Facial asymmetry
- Coloboma of lower eyelid
- External ear anomalies



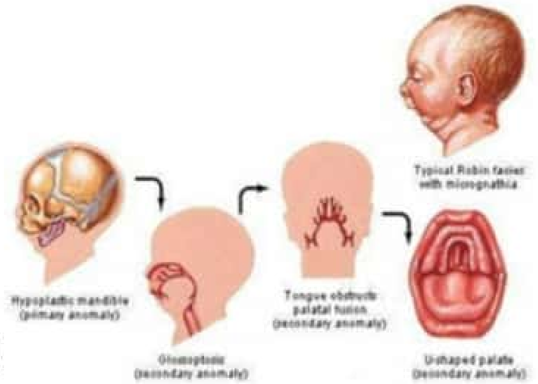
pierre Robinson Syndrome:

Mandible - fails to differentiate

Features:

Hypoblastic mandible → primary anomaly
Glossoptosis - posteriorly displaced tongue
Obstruction of palatal fusion - cleft palate

} secondary anomaly


Typical Robin facies with micrognathia
Hypoplastic mandible (primary anomaly)
Glossoptosis (secondary anomaly)
Tongue obstructs palatal fusion (secondary anomaly)
U-shaped palate (secondary anomaly)

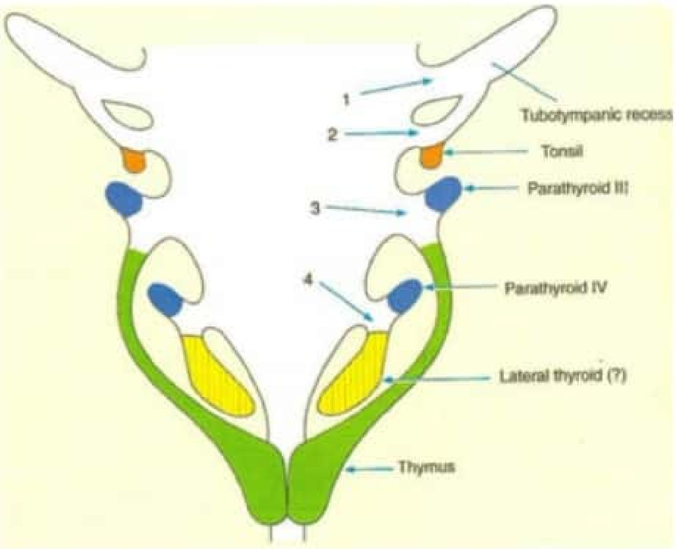
Derivatives of pharyngeal pouches:

I Pouch - Eustachian tube
Middle ear
mastoid antrum

II pouch - Tonsillar fossa
Tonsillar epithelium

III pouch -
ventral : Thymus
Dorsal : parathyroid III → Inferior parathyroid

IV pouch -
ventral : ultimobronchial body → parafollicular cells
Dorsal : parathyroid IV → superior parathyroid



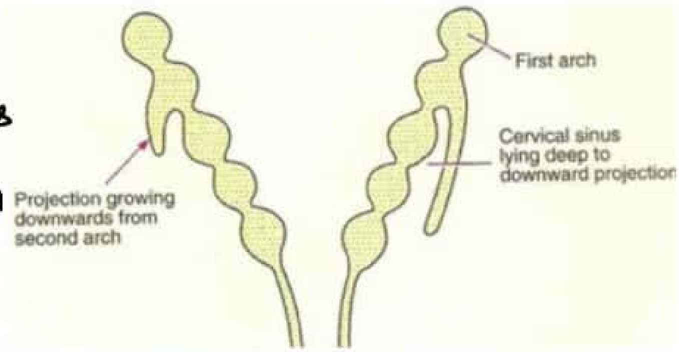
Note:

parafollicular cells derived from :
NCC > ultimobronchial body

Di George Syndrome:
22q11 deletion Syndrome
- Failure of differentiation of 3rd arch
- Thymus & Inferior parathyroid absent

Derivatives of pharyngeal cleft :

I cleft forms external auditory meatus
Growth from II arch → Descend and fuse with the side of VI arch
→ Forms Cervical Sinus → obliteration of II, III, IV clefts


First arch
Cervical sinus lying deep to downward projection
Projection growing downwards from second arch

Branchial cyst:

persisting cervical sinus
Location: anywhere along the anterior border of Sternocleido mastoid muscle

m|c - below angle of mandible

Development of tongue:

Epithelium of tongue:

Anterior $2/3^{rd}$ - surface ectoderm
Posterior $1/3^{rd}$ - Enoderm

Muscles:

myotome of occipital somites (Paraxial mesoderm)
Except : Palatoglossus (IV pharyngeal arch)

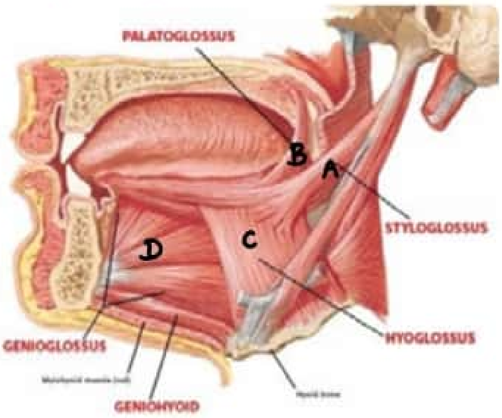
Note:

	Myotome	Derivative
1.	Occipital somites	Tongue
2.	Pre occipital Somites	Extra ocular muscles
3.	Cervical somites	Diaphragm

DNB '18

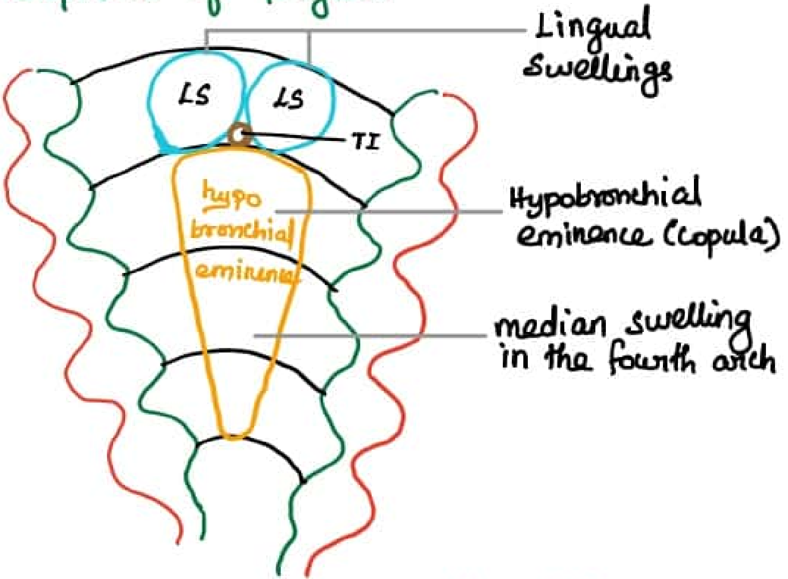
NEET 2017

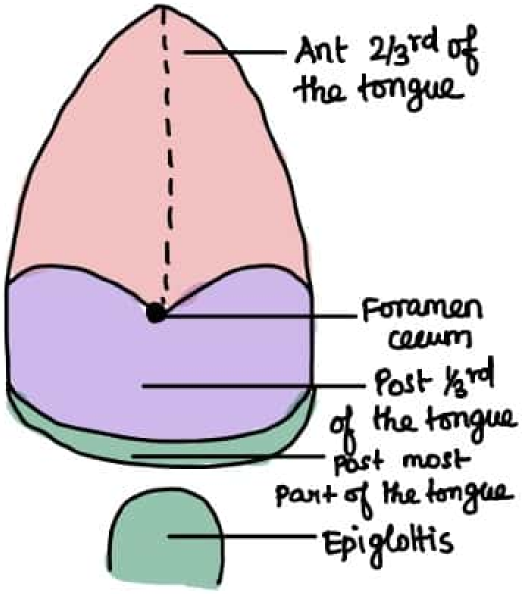
Muscles of tongue - Lateral view:



A - Styloglossus
B - Palatoglossus
C - hyoglossus
D - genioglossus

Development of tongue:

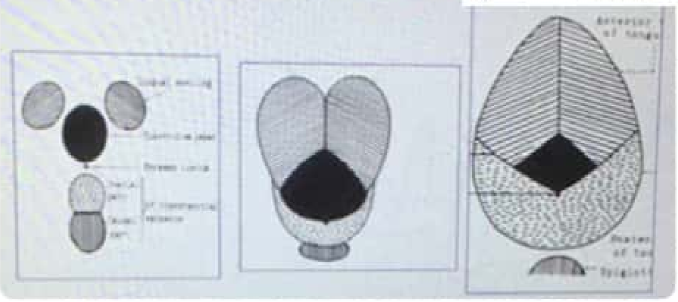

Lingual swellings
LS
LS
TI
hypo bronchial eminence
Hypobronchial eminence (copula)
median swelling in the fourth arch



Floor of I arch : 2 lingual swellings } mesoderm
Tuberculum impar
↓
Forms anterior $2/3^{rd}$ of tongue

Floor of II, III, IV arch - Hypobronchial eminence
Mesoderm of III arch - overgrows II arch mesoderm and fuses with anterior $2/3^{rd}$ of tongue.

∴ II arch mesoderm - Does not contribute to tongue development



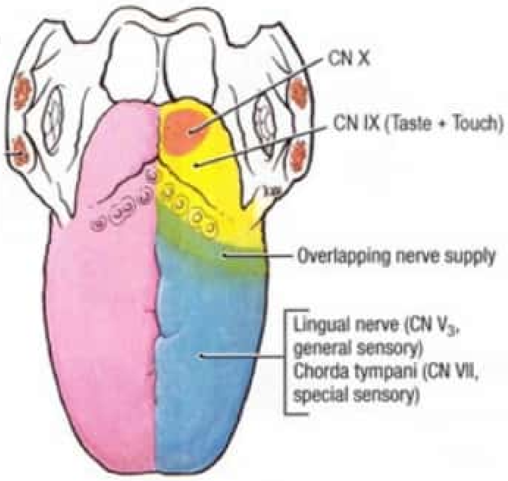
Posterior 1/3rd of tongue
mesoderm of III arch (Hypobranchial eminence)

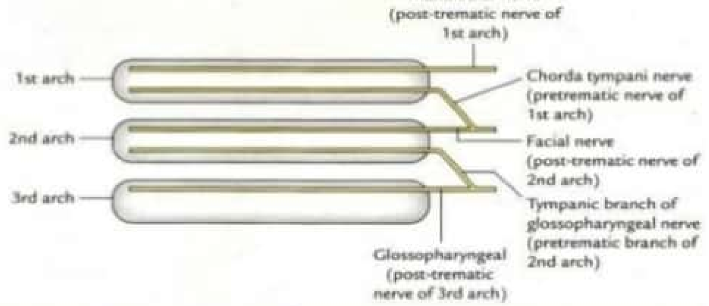
Posterior - most part of tongue and epiglottis
mesoderm of IV arch (hypobranchial eminence)

Nerve supply of tongue:

1. Lingual nerve (branch of mandibular nerve) - general sensation
2. Chorda tympani nerve - taste sensation
3. Glossopharyngeal nerve - general and taste sensation in posterior 1/3
4. vagus nerve - supplies posterior most part

Facial nerve (Nerve of II arch) supplies anterior 2/3rd of tongue via chorda tympani nerve [pre trematic nerve of 1st arch] DNB'18.


CN X
CN IX (Taste + Touch)
Overlapping nerve supply
Lingual nerve (CN V_3, general sensory)
Chorda tympani (CN VII, special sensory)


Mandibular nerve (post-trematic nerve of 1st arch)
1st arch
2nd arch
3rd arch
Chorda tympani nerve (pretrematic nerve of 1st arch)
Facial nerve (post-trematic nerve of 2nd arch)
Tympanic branch of glossopharyngeal nerve (pretrematic branch of 2nd arch)
Glossopharyngeal (post-trematic nerve of 3rd arch)

Pretrematic branch of II arch:
Tympanic branch of glossopharyngeal nerve

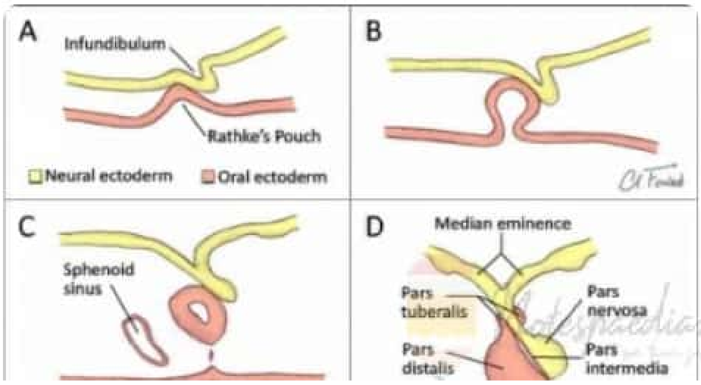
Development of Pituitary and Suprarenal gland:

Pituitary gland:

Stomodaeum - gives rise to bind pouch → Rathke's pouch (Surface ectoderm)
↓ Forms
Adenohypophysis
[Pars anterior, Pars tuberalis, Pars intermedia]

2. Pars nervosa - Derived from neuroectoderm

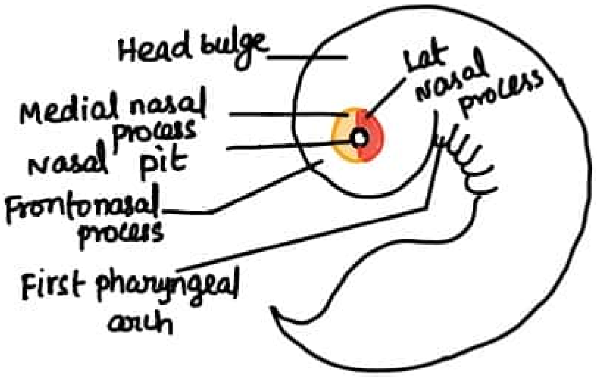
Neuro ectoderm
↓
Neural tube
↓
Prosencephalon
↓
Diencephalon
↓
Infundibulum
↓

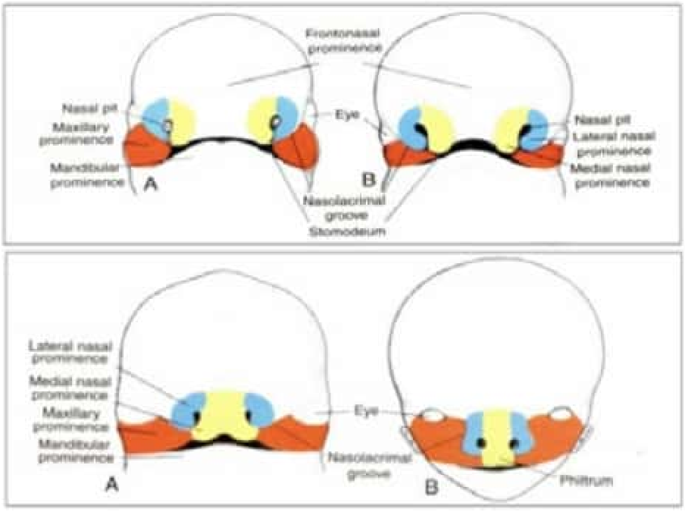


Supra renal gland:

Adrenal cortex - Intermediate mesoderm
Adrenal medulla [Post ganglionic sympathetic neurons]
↓
Derived from neural crest cells

Development of face:





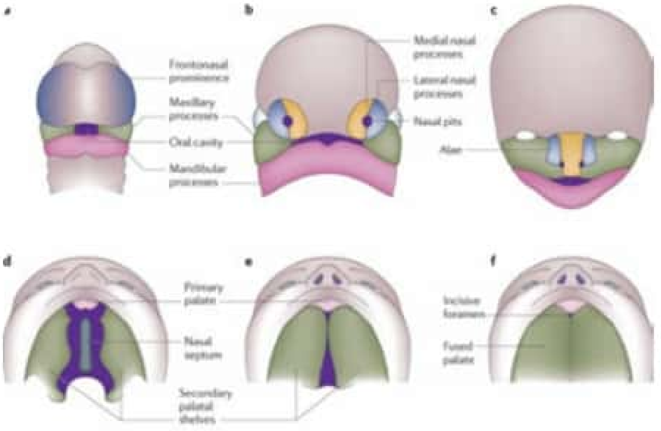
Face:
Derived from: Frontonasal process
Medial & lateral nasal process - MNP & LNP
Maxillary process
Mandibular process

Medial nasal process - Fuse with each other - Forms philtrum and primitive Palate

Lateral nasal process - Ala and side of Nose
Maxillary process - upper lip and cheek
Mandibular process → Fuse with each other → lower lip and chin

1. medial nasal process fuses with maxillary process
2. maxillary process fuses with MNP & LNP

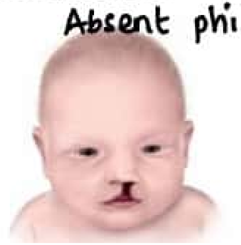
Development of Palate:



Primary palate: derived from medial nasal process.
Secondary palate: derived from maxillary process
Incise foramen - Formed at junction of primary & secondary Palate

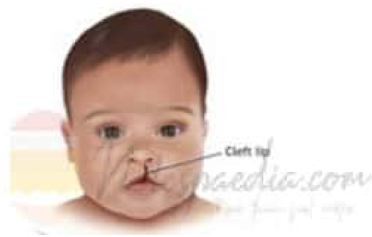
Midline cleft lip:

MNP fails to fuse with each other.
Absent philtrum

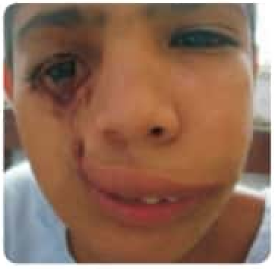


Cleft upper lip:

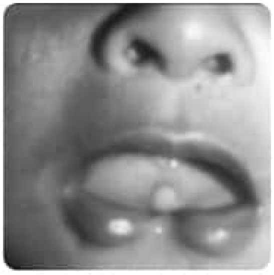
maxillary process fails to fuse with MNP



oblique facial cleft:
Failure of fusion of maxillary process to LNP

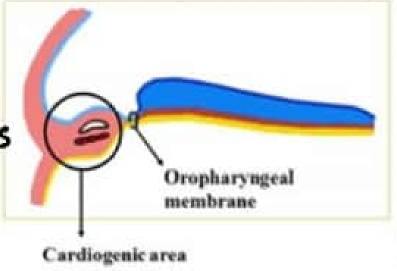


cleft lower lip:
Failure of fusion of mandibular process.



DEVELOPMENT OF HEART TUBE

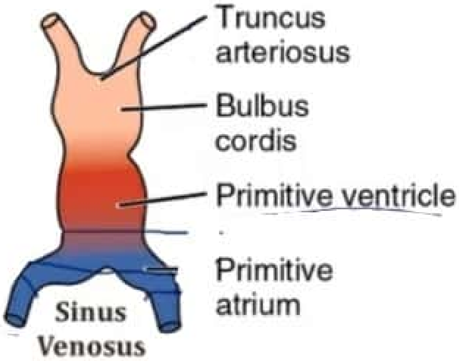
Development of heart tube:
Heart develops from the Cardiogenic area
↓
Splanchnopleuric lateral mesoderm
cranial to oropharyngeal membrane
In the middle of 3rd week
↓
Angioblastic cord cell → Forms two endothelial heart tube
The two endothelial heart tube → joins and form heart tube
↓
undergoes series of dilatations
↓
Forms various parts of heart



Truncus arteriosus - Forms outflow track - aorta and pulmonary trunk
Bulbus cordis - smooth wall of Right ventricle / Left ventricle
primitive ventricle - Rough part of Right ventricle / Left ventricle
primitive atrium - Rough part of Right atrium / left atrium
Body & Right horn of sinus venosus - smooth wall of Right atrium
left horn of sinus venosus - Forms coronary sinus
Smooth wall of left atrium - Formed due to absorption of pulmonary veins

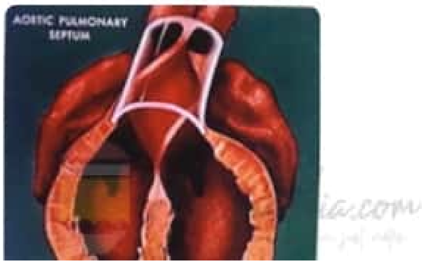
Conotruncal Septum:
Derived from neural crest cells
Spiral in nature
Aka Spiral septum / Aorticopulmonary septum
This septum divides Truncus arteriosus into

- Aorta
- Pulmonary trunk



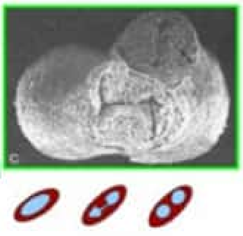
The blood from Right ventricle → pulmonary trunk
The blood from left ventricle → Aorta

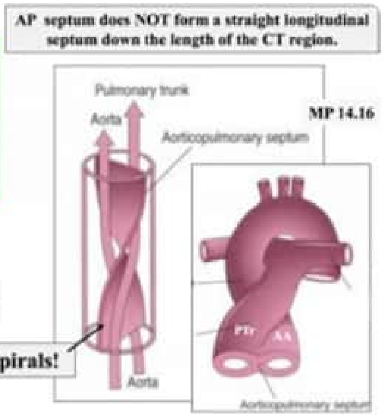
The anterior displacement of Conotruncal septum leads to Tetrology of Fallot

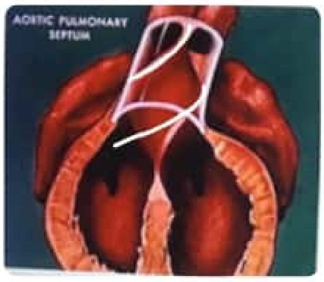


Tetralogy of Fallot

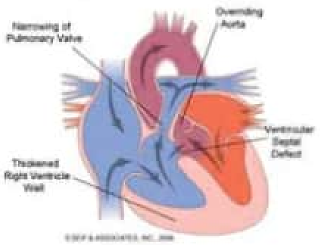
- Pulmonary Stenosis
- overriding aorta (aortic orifice receives blood from Right & left ventricle)
- Right ventricle hypertrophy (due to pulmonary Stenosis)
- VSD ventricular septal defect


CTCs fuse to form AP septum.
Divides lumen into equal halves


AP septum does NOT form a straight longitudinal septum down the length of the CT region.

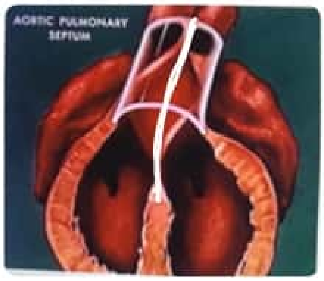


Tetralogy of Fallot


Narrowing of Pulmonary Valve
Overriding Aorta
Ventricular Septal Defect
Thickened Right Ventricle Wall

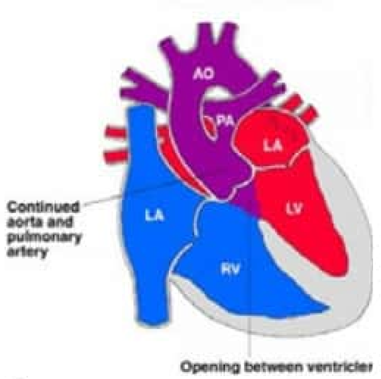
Anomalies of conotruncal septum:

If the conotruncal septum - is straight
↓
Non - Spiral course of conotruncal septum
↓
Right ventricle → Drains into Aorta
Left ventricle → Drains into pulmonary trunk
↓
Transposition of great vessels



If Neural crest cells - fail to migrate
↓
The truncus arteriosus will persist
↓
Persistent truncus arteriosus

Truncus Arteriosus


AO
PA
LA
LA
LV
RV
Continued aorta and pulmonary artery
Opening between ventricles

Development of Interatrial septum:

In intrauterine life - There is shunt from right atrium to left atrium
↓
Because lungs are not functioning in intrauterine life

The Septum primum forms in atrium
↓
Between the AV cushion and septum primum there is an opening - ostium primum
↓
So blood - through ostium primum flows from Right atrium to left atrium

The septum primum gradually grows towards AV cushion
↓
ostium primum gets narrowed

The septum primum fuses with AV cushion
↓
But with a opening in the center
↓
ostium secundum

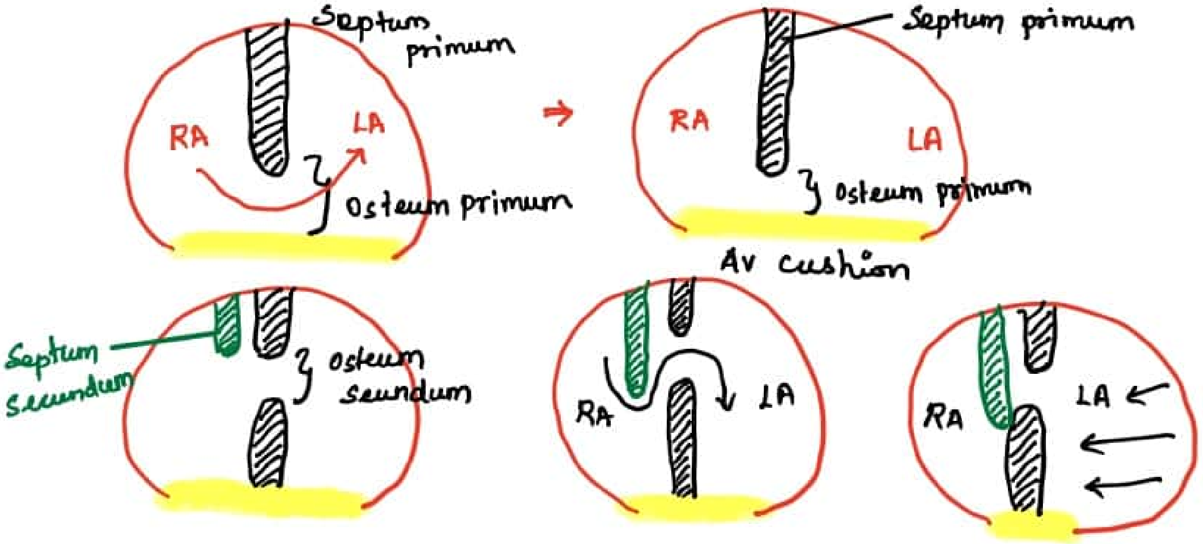
The septum secundum is formed adjacent to septum primum

The septum primum grows gradually towards AV cushion

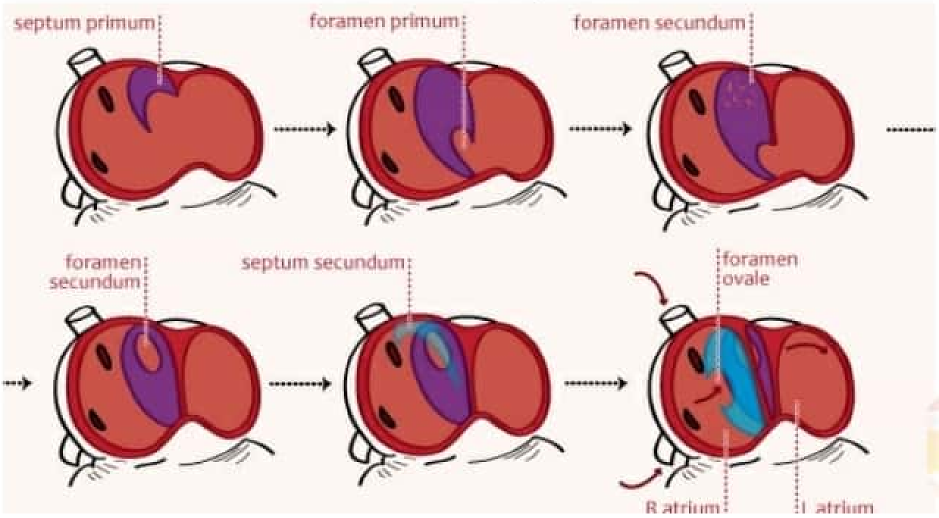
The blood from right atrium passes through the gap between septum secundum and septum primum
↓
And passes through the ostium secundum
↓
Reaches left atrium

The gap between septum primum and septum secundum – Foramen ovale

After birth – left atrium receives blood from the lungs
↓
so ↑ pressure in left atrium
↓
This leads to fusion of septum primum and septum secundum



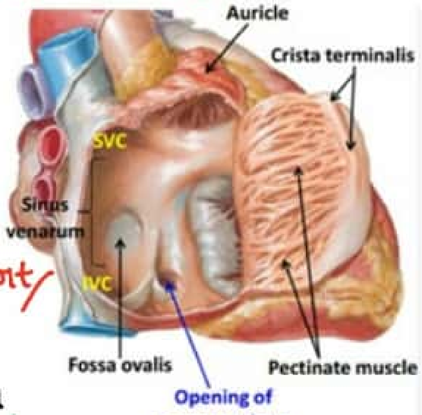
Interatrial Septum



Remnants of Interatrial Septum:

In 20% of people gap between septum secundum & septum primum persists
↓
Called - Probe Patency of foramen ovale
(anatomically present, physiologically closed)

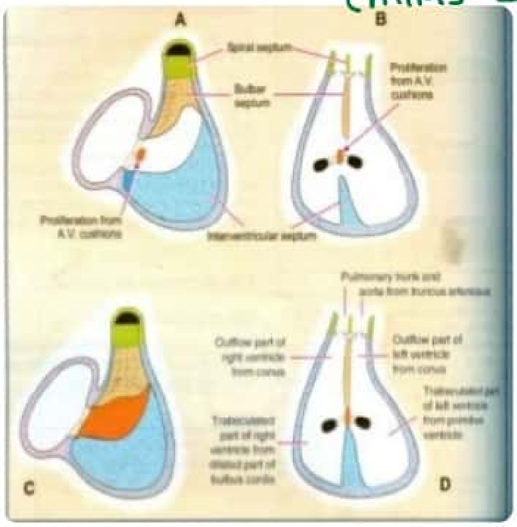
The septum primum - forms fossa ovalis }
The septum secundum - forms Limbus fossa ovalis } (Jipmer - 2018)



Development of Interventricular septum:

There are three parts of interventricular septum

- Muscular part
  ↓
  develops from myocardium
- membranous part
  ↓
  Develops from Endocardial cushion (AIIMS - 2019)
- Infundibular part/ outflow part
  ↓
  Develops from conus septum/ bulbar septum
  ↓
  Derived from Neural crest cells.


A
B
C
D
Spiral septum
Bulbar septum
Proliferation from A.V. cushions
Proliferation from A.V. cushions
Interventricular septum
Pulmonary trunk and aorta from truncus arteriosus
Outflow part of right ventricle from conus
Outflow part of left ventricle from conus
Trabeculated part of left ventricle from primitive ventricle
Trabeculated part of right ventricle from dilated part of bulbus cordis

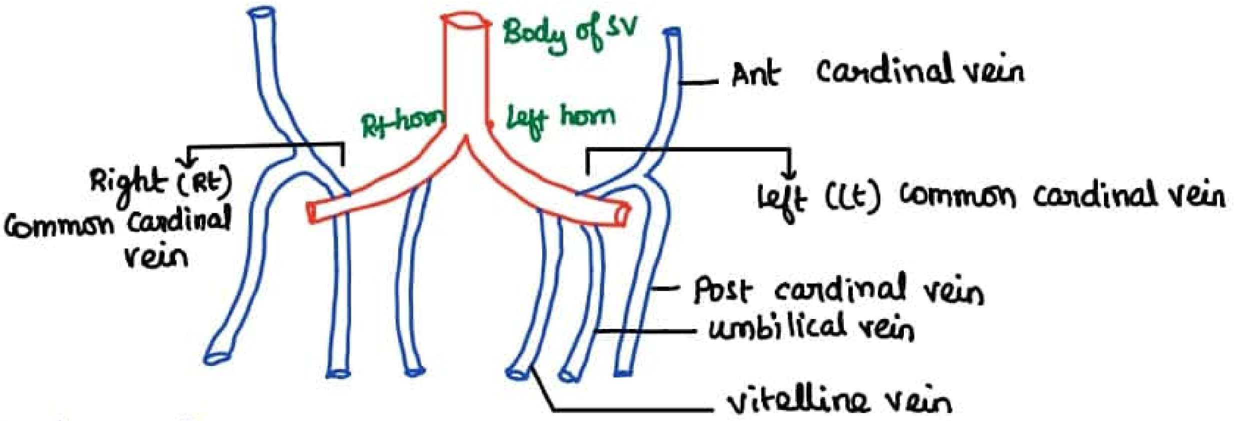
---

Development of veins

Introduction:

By the end of 5th week

- common cardinal vein
  ↓
  Drains from embryo proper
  ↓
  Into sinus venosus (SV)
- vitelline vein
  ↓
  Drains from yolk sac
  ↓
  to sinus venosus
- umbilical vein
  ↓
  Drains from placenta (oxygenated blood)
  ↓
  to sinus venosus



Vitelline veins:

The vitelline veins form a plexus (anastomosis) around the duodenum
↓

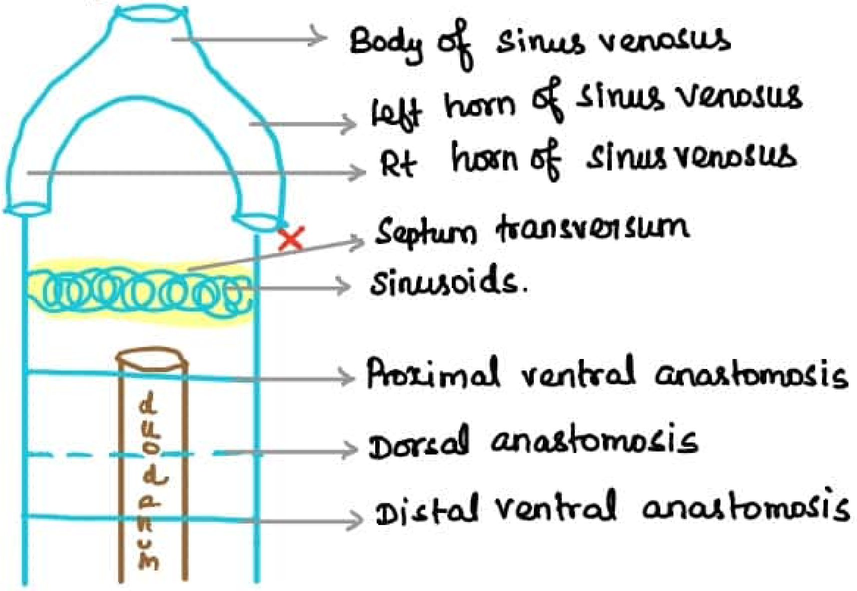
- Proximal ventral anastomosis
- Dorsal anastomosis
- Distal ventral anastomosis

- This plexus passes through the septum transversum
↓
And drains in Right & left horn of SV.

The vitelline vein pass through the septum transversum
↓
Liver cords formed in the septum transversum disturbs the course of vitelline vein
↓
Forms Sinusoids in the septum transversum

The left horn of SV - forms coronary sinus

The cranial part of left vitelline vein - disappears.

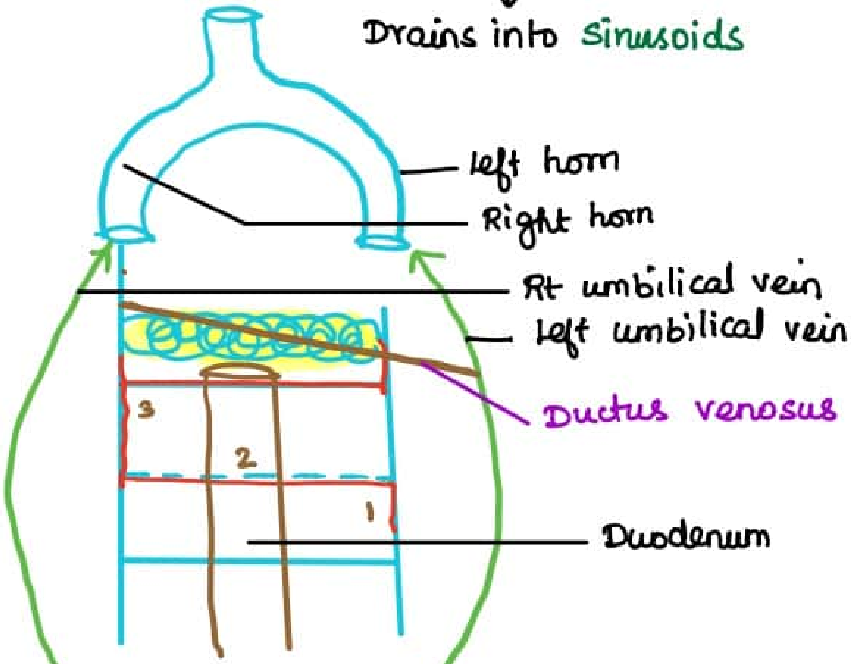


Portal vein:

Sources for formation:
↓

- Small part of left vitelline vein
- Dorsal anastomosis
- Right vitelline vein + proximal ventral anastomosis

Portal vein - enters liver
↓
Drains into sinusoids



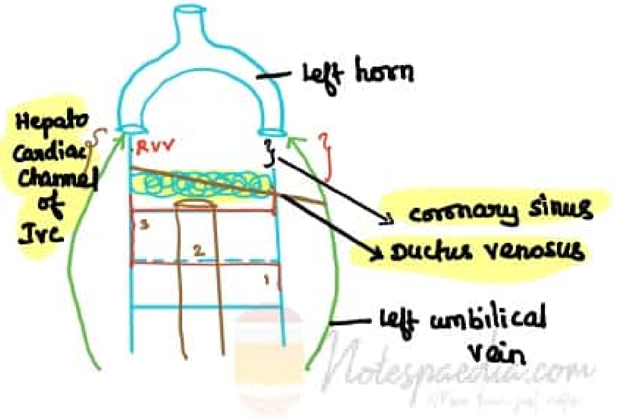
The Right umbilical vein will disappear
The site of regression of right umbilical vein - forms potential site for hernia gastrochisis.

Ductus venosus formation:

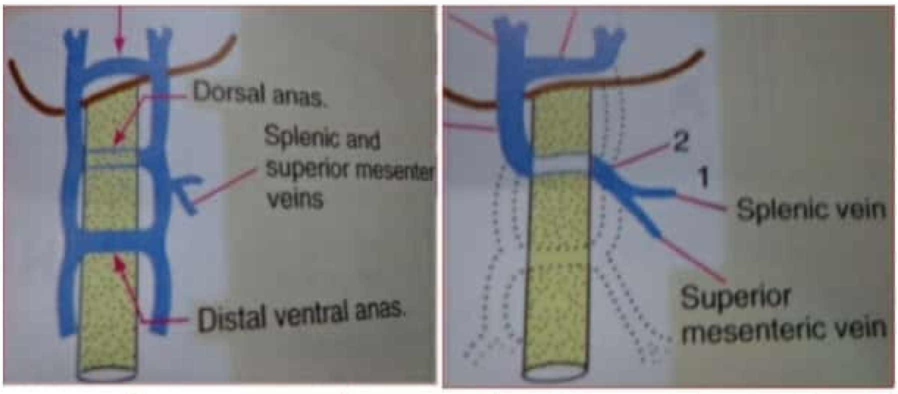
The cranial part of left umbilical vein - disappear
↓
Because left horn of sv forms coronary sinus
The left umbilical vein (carrying oxygenated blood)
↓
Shunts the blood to Right vitelline vein
↓
Through Ductus venosus
The cranial part of Right vitelline vein - Forms cranial IVC (inferior vena cava)
↓
Hepato cardiac channel of IVC
Hence, ductus venosus - shunts of blood from left umbilical vein to IVC (without passing through liver)

The remnants, after birth

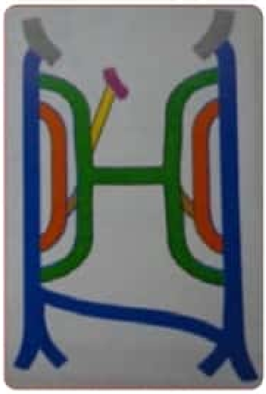
- Left umbilical vein
  ↓
  Forms ligamentum teres
- Ductus venosus
  ↓
  Forms ligamentum venosum



How the portal vein is formed??



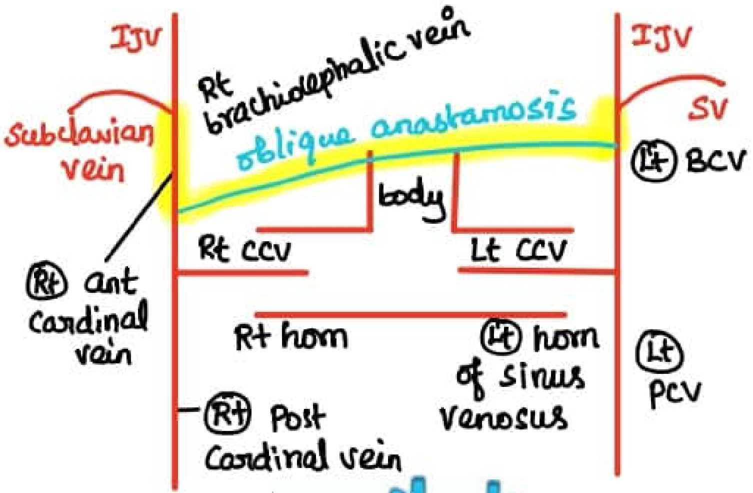
Development of subclavian vein, Internal jugular vein, brachiocephalic vein:



- The subclavian vein (Right & left) - Derived from intersegmental veins
- The Internal jugular vein (IJV) (Right & left)
  ↓
  Derived from anterior cardinal vein above the subclavian vein opening
- There is an Oblique anastomosis formed between right & left Cardinal vein
- The Right brachiocephalic vein
  ↓
  Derived from oblique anastomosis + left anterior cardinal vein below the subclavian vein opening

Development of superior vena cava:

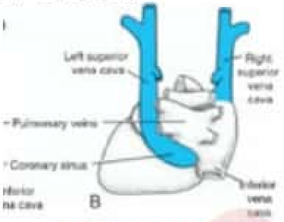
Derived from
↓ Right anterior cardinal vein below the oblique anastomosis
↓ Right common cardinal vein



The right SVC drains into Right horn of SV - which in turn forms smooth wall of Right atrium

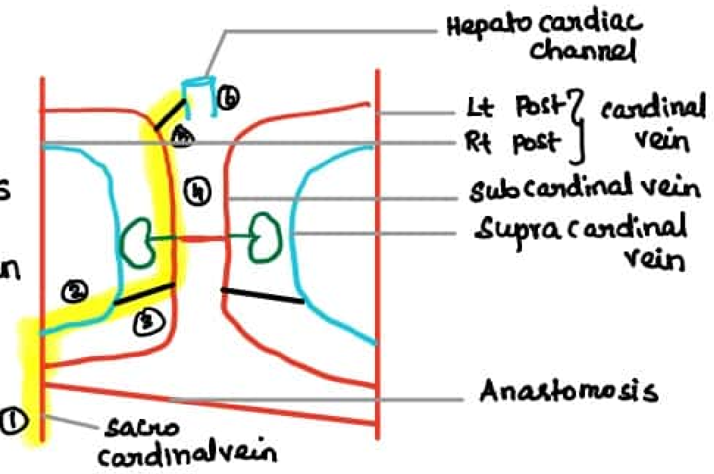
The left SVC drains into - Left horn of SV - coronary sinus

clinical correlation - Double Superior Venacava
↓
Due to
- No oblique anastomosis
- Persistence of left anterior cardinal vein



Double superior vena cava. The communicating (brachiocephalic) vein between the two anterior cardinals has failed to develop (dorsal view)

Development of Inferior venacava:



The lower part of posterior cardinal vein - Sacrocardinal vein

The Subcordinal vein - Drains the kidneys

The Supracardinal vein - Drains the body wall through the intercostal vein

The hepatocardiac channel - Derived from right vitelline vein

There are 3 anastomosis between

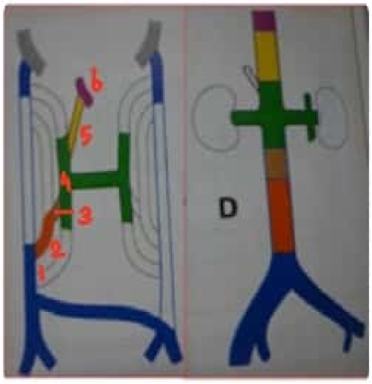
↓ Two subcordinal veins

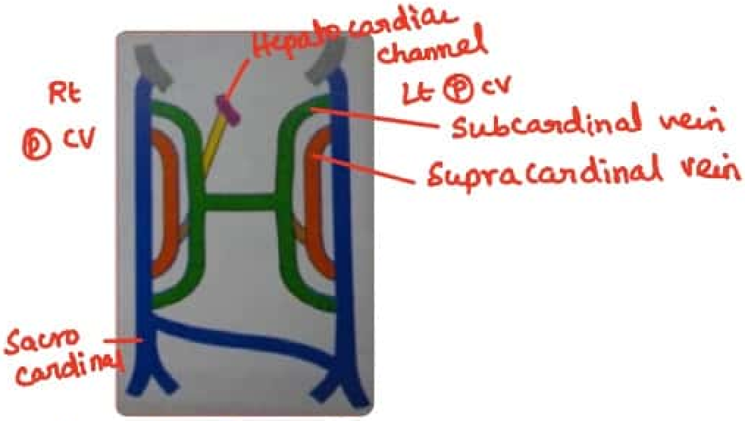
↓ Supracardinal & Subcordinal vein

↓ Subcordinal vein & hepatocardinal channel

Source of IVC formation
↓

1. Right Sacrocardinal vein
2. Right Supra cardinal vein
3. Anastomosis between right Supra cardinal vein and Subcordinal vein (Right)
4. Right Subcordinal vein
5. Anastomosis between subcordinal vein & hepatocardiac channel
6. Right hepatocardiac channel.

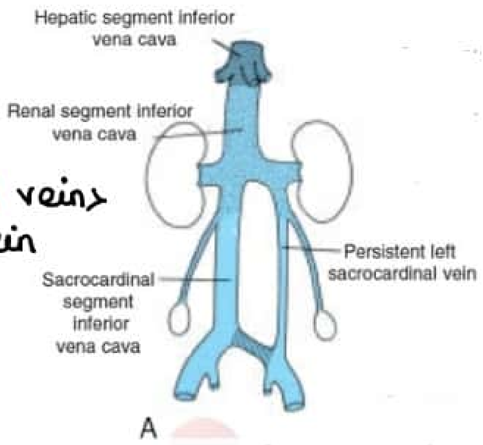




Double inferior vena cava and Renal veins development:

The IVC develops from right side veins
↓
All the left side veins - disappears

Double IVC - is due to the persistence of
↓
left sacrocardinal vein vein > left Subcordinal vein > left supracordinal vein


Hepatic segment inferior vena cava
Renal segment inferior vena cava
Persistent left sacrocardinal vein
Sacrocardinal segment inferior vena cava
A

Development of Renal vein:

Right renal vein - Derived from Right mesonephric vein

Left Renal vein - Derived from

↓ Anastomosis between + ↓ left + ↓ left

Development of Suprarenal vein and gonadal vein :

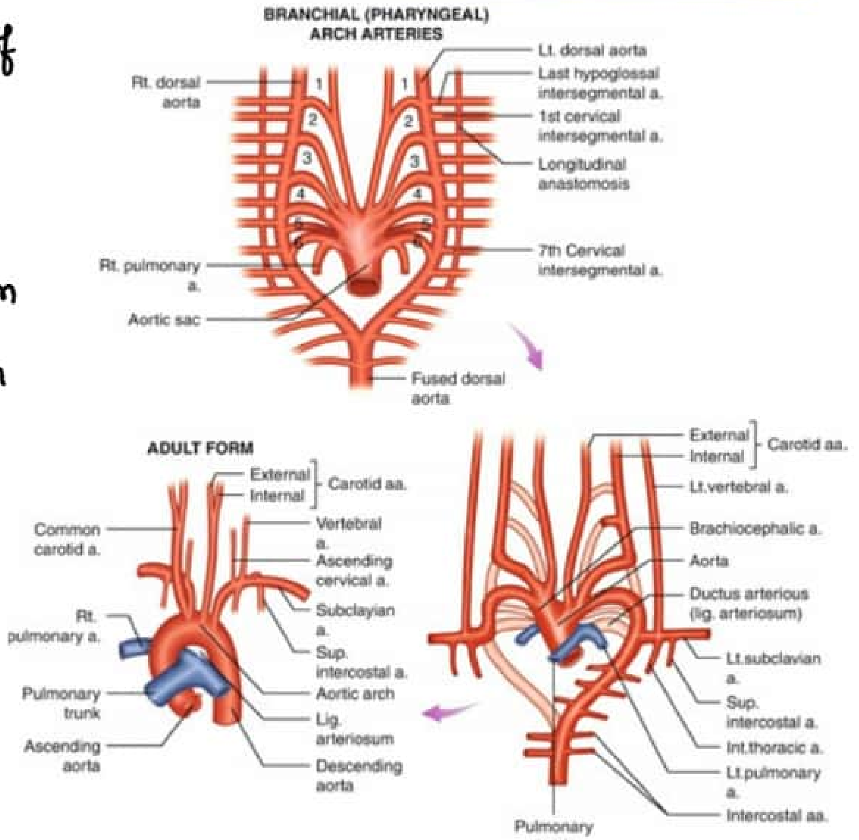
Right cranial Subcardinal vein
↓
Forms right Suprarenal vein → Drains into IVC
Right caudal subcardinal vein
↓
Forms Right gonadal vein → Drains into IVC
Left cranial Subcardinal vein
↓
Forms left Suprarenal vein → Drains into left renal vein
Left caudal Subcardinal vein
↓
Forms left gonadal vein → Drains into left renal vein

DEVELOPMENT OF PHARYNGEAL ARCH ARTERIES

Aortic Sac: Cranial most Part of Truncus arteriosus

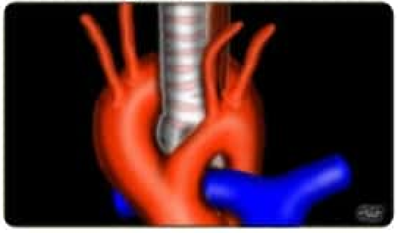
1st & 2nd Arch arteries disappear
Remnant → stapedial artery
Remnant → maxillary artery

- 3 & 4 Arch artery - In continuum with ascending aorta
- 6th arch artery - In continuum with pulmonary trunk



Arch of aorta:
→ Left horn of Aortic sac + Ⓛ 4th Arch artery + Ⓛ dorsal aorta (caudal part)
→ corresponding Ⓡ dorsal aorta caudal part → Disappear

Double aortic arch:
Due to persistence of both Ⓡ & Ⓛ part of dorsal aorta.



- Ⓛ Brachiocephalic Trunk → Right horn of Aortic Sac
- Common carotid artery → Proximal part of 3rd arch artery
- External carotid artery → Carotid bud formed on 3rd arch artery

- Internal carotid artery → Distal part of 3rd Arch artery
  +
  Cranial part of Dorsal aorta

Development of Subclavian artery:

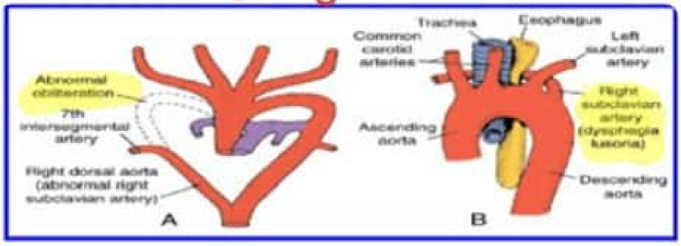
(Rt) Subclavian artery → Ⓡ 4th arch artery
+
Ⓡ dorsal aorta cranial to 7th cervical intersegmental artery
+
Ⓡ 7th cervical intersegmental artery

4th arch artery forms → Ⓡ side - Ⓡ Subclavian artery
Ⓛ side - Arch of aorta

Ⓛ subclavian artery → Ⓛ 7th cervical intersegmental artery

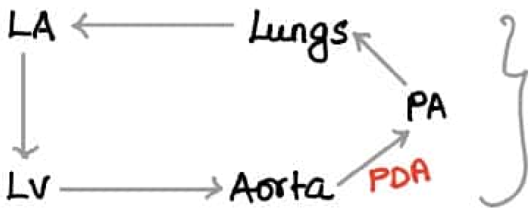
Abnormal Ⓡ Subclavian artery:

- Ⓡ 4th arch artery, Ⓡ dorsal aorta cranial to 7th cervical intersegmental artery → disappears
- Ⓡ 7th cervical intersegmental artery Ⓡ dorsal aorta Caudal to 7th cervical intersegmental artery → Persist
- Cause Dysphagia lusoria due to compression of oesophagus


Abnormal obliteration
7th intersegmental artery
Right dorsal aorta (abnormal right subclavian artery)
A
Trachea
Oesophagus
Common carotid arteries
Left subclavian artery
Right subclavian artery (dysphagia lusoria)
Ascending aorta
Descending aorta
B

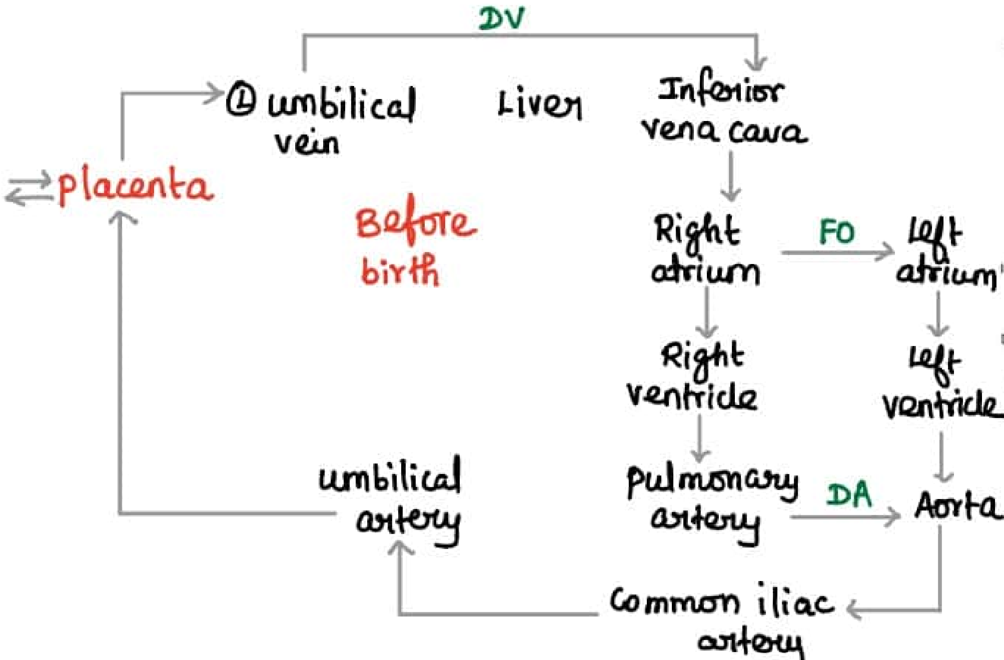
Development of Pulmonary artery and ductus arteriosus:

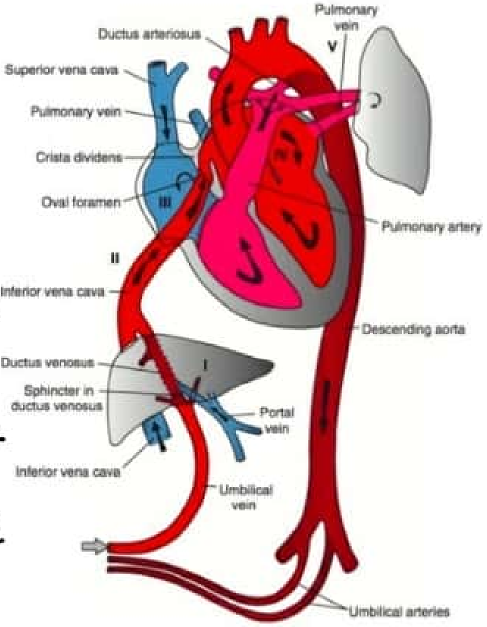
Pulmonary artery → Proximal part of 6th arch artery
Ductus arteriosus → Distal part of Ⓛ 6th arch artery
↓
connect pulmonary artery to arch of aorta
closes immediately after birth
Persists in PDA (Patent Ductus arteriosus)
→ Acyanotic heart disease



circulation of oxygenated blood

Fetal circulation





DV = Ductus venosus DA = Ductus arteriosus
FO = Foramen ovale

changes in fetal circulation after birth:

Occlusion of umbilical artery (physiological closure – after birth
Anatomical closure - 2-3 month)
- → Proximal part ——→ from superior vesical artery
- → Distal part ——→ from medial umbilical ligament

Occlusion of umbilical vein & Ductus venosus
Shortly after occlusion of umbilical artery
left umbilical vein → Ligamentum teres Hepatis
Ductus venosus → Ligamentum venosum

Occlusion of Ductus Arteriosus
↓ forms
Ligamentum Arteriosum
[physiological closure - immediatly after birth
Anatomical closure - 1-3 months]

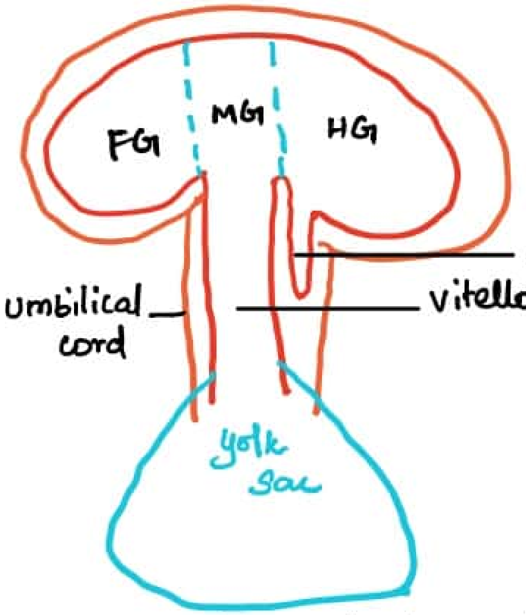
Occlusion of foramen ovale → Due to ↑ pressure in left atrium

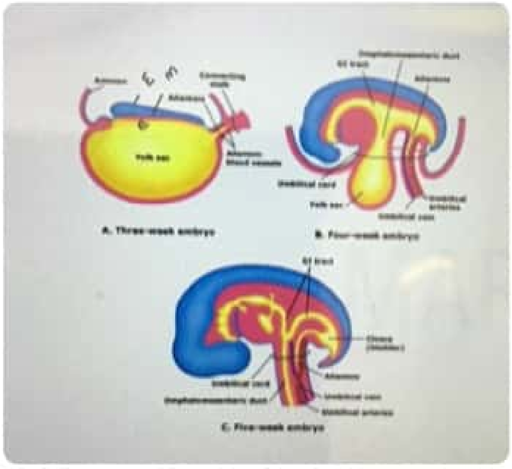
Probe patency of foramen ovale →
20% population : Persistence of gap between
septum secundum & septum primum
septum secundum ↓ Limbus fossa ovalis
septum primum ↓ Fossa oralis

DEVELOPMENT OF FOREGUT

Development of foregut :

Gut epithelium derived from → Endoderm of yolk sack





A. Three-week embryo

B. Four-week embryo

C. Five-week embryo

Contents of umbilical cord:
- Vitellointestinal duct
- Allantois
- left umbilical vein
- Ⓡ & Ⓛ umbilical artery
- wharton's jelly

		Artery	Sympathetic supply
Forgut	→ upto 2nd part of duodenum [ampula of vater]	→ celiac artery	Greater splanchnic nerve ($T_5 - T_9$)
Midgut	→ up to transverse colon Right 2/3rd	Superior mesenteric artery (SMA	lesser splanchnic nerve $T_{10} - T_{11}$
Hind gut	→ Rest of the gut till anal canal	Inf. mesenteric artery (IMA)	least splanchnic nerve (T_{12}) Lumbar splanchnic nerve ($L_1 - L_2$)

Pain fibers are carried by Sympathetic fibers only

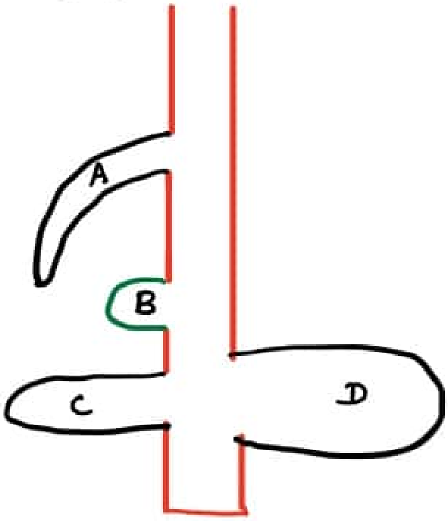
Umbilicus →

level of L_{3-4}

Dermatome : T_{10} → In appendicitis referred pain in umbilical area

Parasympathetic supply:
Foregut → vagus nerve
Midgut → vagus nerve
Hind gut → Pelvic splanchnic nerve ($S_{2,3,4}$)
↓
"only splanchnic nerve to carry parasympathetic fiber"

Development of foregut:

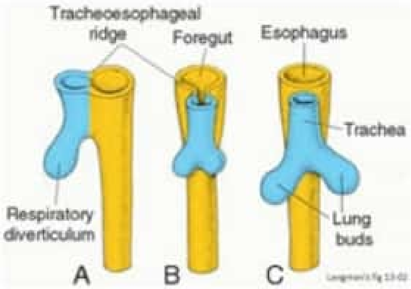


Splitting of foregut into esophagus and trachea

A. Respiratory diverticulum
B. Hepatic bud
C. Ventral pancreatic bud
D. Dorsal pancreatic bud

Respiratory diverticulum:
Proximal part → laryngotracheal diverticulum
Distal part → bronchial & Lung bud

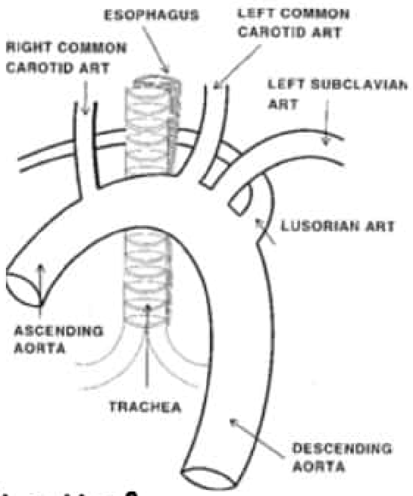
Development of esophagus:



Tracheo-esophageal ridges: longitudinal ridges that eventually fuse to separate trachea from esophagus.

Tracheo-esophageal septum: separates trachea & esophagus
Ventral part – trachea
Dorsal part – esophagus

Anomalies:
- Esophageal atresia: Tracheo-esophageal septum divides posteriorly
↓
polyhydramnios
- Lusarian artery:
Abnormal Ⓡ subclavian artery goes behind esophagus
↓
compresses esophagus
↓
$\boxed{\text{Dysphagia lusoria}}$



Development of stomach:

Stomach → Rotates 2 times (clock wise direction)
- 1st Rotation – clockwise direction
– vertical axis

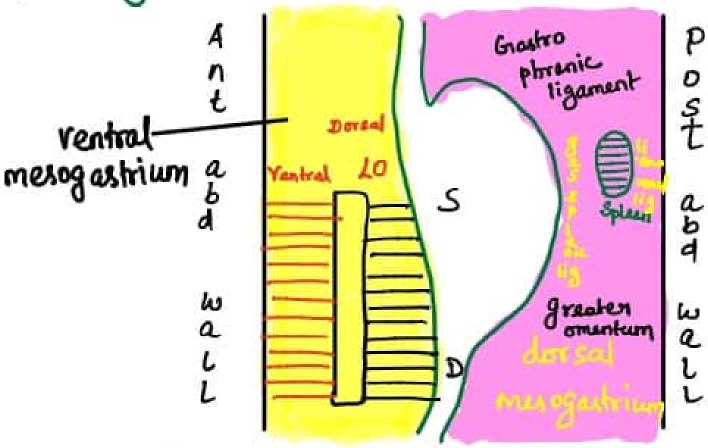
Anterior border becomes → Ⓡ border
lesser curvature
Posterior border becomes → Ⓛ border
Greater curvature

∴ Ⓛ vagus on Ⓛ border → superficial → Ant. vagal trunk
Ⓡ vagus → Deep plane (posterior) → Post vagal trunk

- 2nd Rotation - clockwise direction
  - Anteroposterior axis

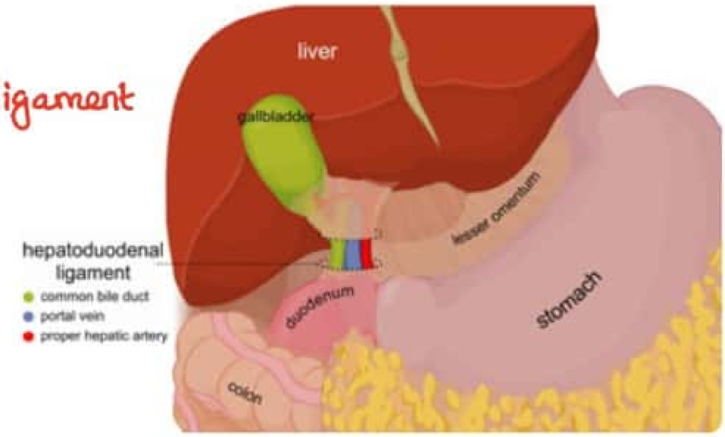
  Cardiac end → Ⓛ side
  pyloric end → Ⓡ side

Mesentry around stomach:



Mesogastrium :

- Derivatives of ventral mesogastrium
  - lesser omentum → Derived from dorsal part of ventral mesogastrium
    - Hepatogastric
    - Hepato duodenal
  - Falciform ligament → Derived from ventral part of ventral mesogastrium
    - coronary ligament
    - Triangular ligament

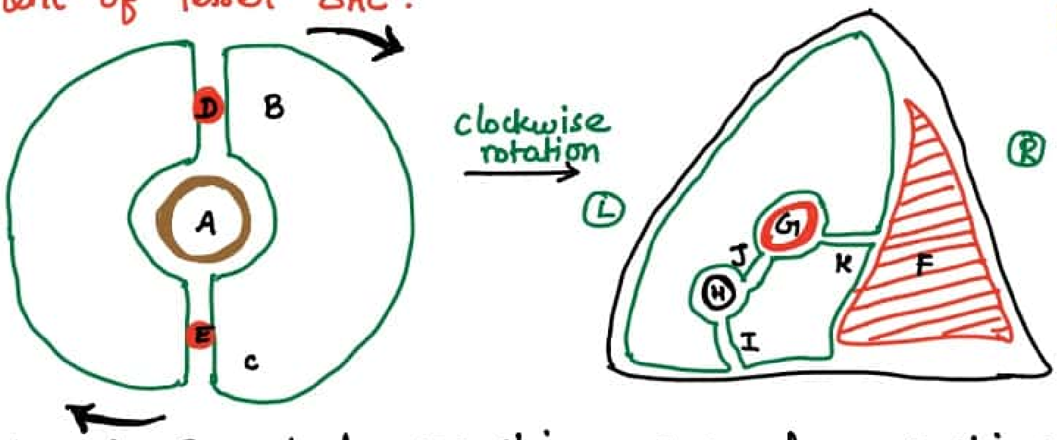


Derivatives of dorsal mesogastrium:
- Gastrosplenic ligament
- Leinorenal ligament
- Greater omentum
- Gastrophrenic ligament

Hypertropic pyloric stenosis:

- muscularis externus in pyloric region
  → Hypertropy
  ⇓
  Pyloric stenosis
- Palpable mass at (Rt) costal margin
- projectile Non bilious vomiting immediately after feeding

Development of lesser SAC :



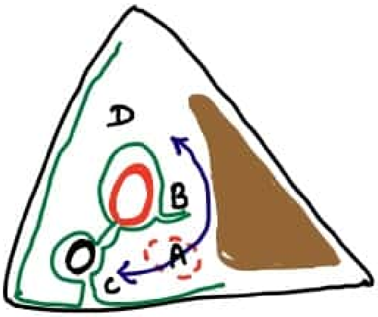
A-stomach , B-ventral mesogastrium , C-Dorsal mesogastrium
D- Liver, E- spleen, F-Liver, G- stomach, H-spleen, L- leinorenal ligament
J- gastrosplenic ligament, K- lesser omentum

Lesser sac- space formed behind the stomach due to clockwise rotation of stomach

"spleen is projecting into greater sac"

Epiploic foramen (A):

Connect greater (D) & Lesser sac (C)

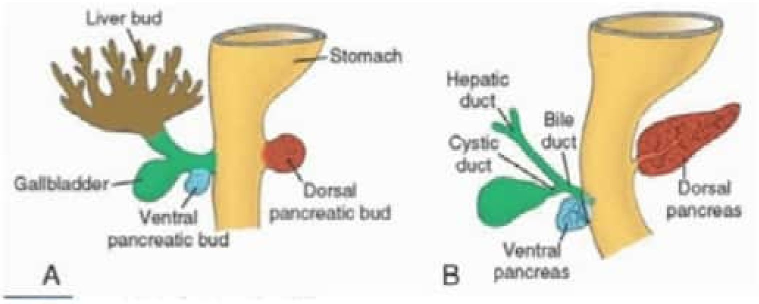


Boundaries:

Anteriorly - Ⓡ free margin of lesser omentum (B)
Posteriorly- Inferior vena cava
Above - Caudate lobe of liver
Below 1st part of duodenum

Development of Liver & Pancreas :

Regional Organogenesis: Liver & Pancreas



Hepatic bud:

- Formed in foregut tube
- Forms parenchyma of liver & biliary system

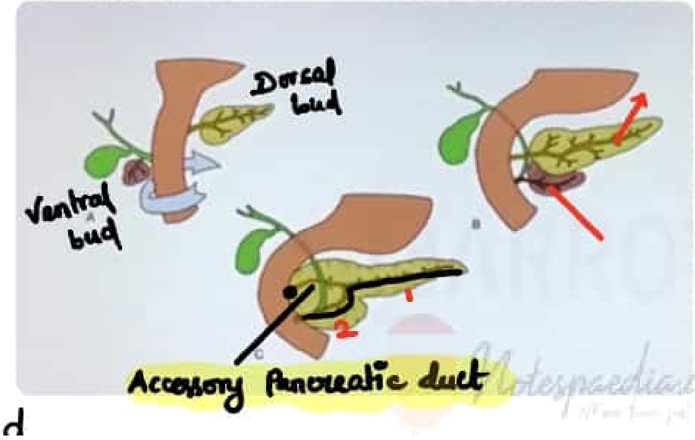
Liver also derived from septum transversum
↓
- connective tissue of liver
- Capsule
- Sinusoids
- Kupffer cells

Development of Pancreas:

-Duodenum rotates to Ⓡ side & forms 'c' shaped loop, due to this ventral bud moves dorsally & lie below the dorsal bud

- ventral bud will form lower part of head of pancreas & uncinate process

remaining part if formed by dorsal bud



Duct of Pancreas:

- Dorsal bud = Dorsal duct }
- Ventral bud = Ventral duct } main pancreatic duct = Distal part of dorsal duct + ventral duct

Main pancreatic duct join's with common bile duct and forms Ampulla of vater → Opens into major duodenal Papillae

Accessory pancreatic duct → proximal part of dorsal bud open into minor duodenal papillae

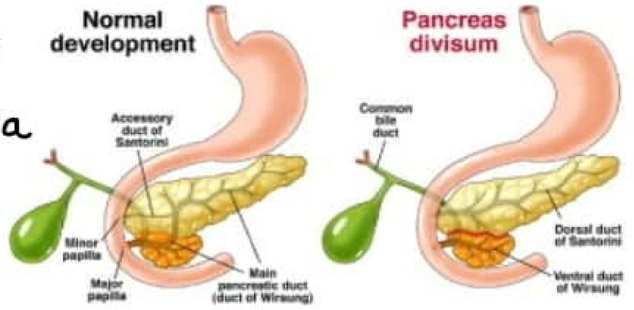
Pancreatic divisum:

M/c anomaly in development of Pancreas

ventral & dorsal duct remain separated

Dorsal duct $\xrightarrow[\text{into}]{\text{opens}}$ minor duodenal papilla

ventral duct ⟶ major duodenal papilla



Annular pancreas:

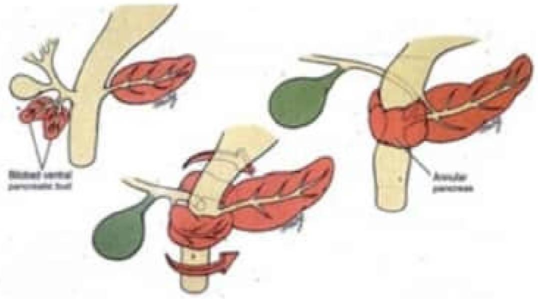
Form a ring around duodenum due to Bilobed ventral bud

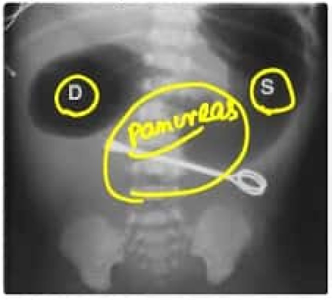
xray: Annular pancreas (one lobe migrates along the usual pathway & other lobe migrates in opposite direction)

↓

Loss of continuity of duodenum

"double bubble sign"





Development of duodenum:

- upto 2nd part of duodenum → foregut ⟶ celiac trunk (ampulla of vater)
- Rest of duodenum → midgut → Sup. mesetric artery
- due to rotation of stomach - duodenum rotates to right
- mesoduodenum - extends from duodenum to posterior Abdomen wall

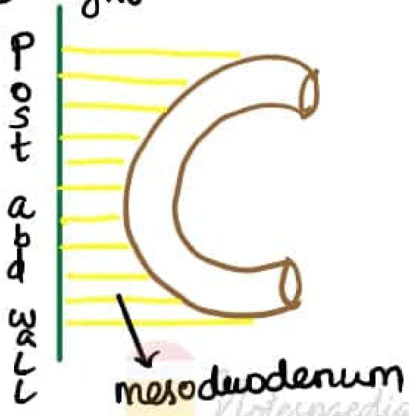
↓

It disappears later

↓

Duodenum becomes retroperitoneal [except the proximal part - intra parietal]

- proximal part of duodenum → Hepato duodenal part of lesser omentum

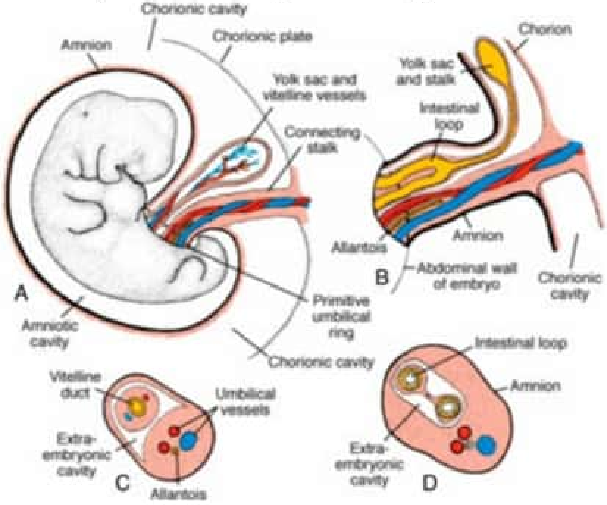


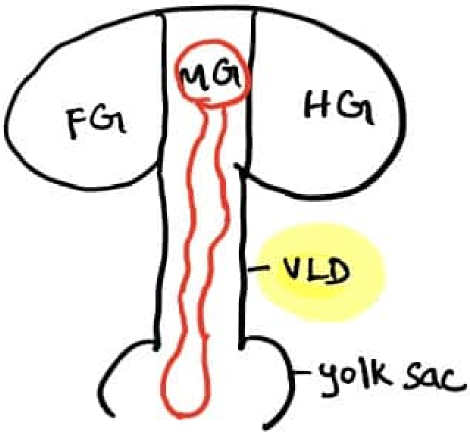
DEVELOPMENT OF MIDGUT

Development of midgut:

From 2nd part of duodenum to transverse colon at the junction of right 2/3rd and left 1/3rd

Components of midgut:





Superior mesenteric artery divides:

Midgut

pre-arterial segment
- Duodenum
- Jejunum
- Ileum

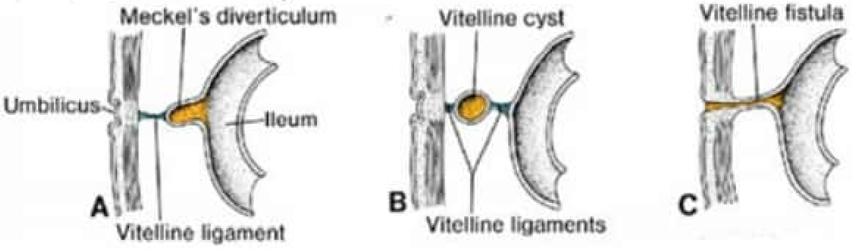
Post arterial segment
- Caecum
- Appendix
- Ascending colon
- Transverse colon

physiological hernia:

6th week

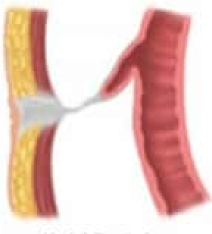
midgut contents herniate into yolksac through vitello intestinal duct (VID)

In 2% population persistent VID → meckel's diverticulum



Rule of 2:

Seen in 2% of population
2 inch long
2 feet distant from Ileocaecal valve
Location → Anti mesenteric border of Ileum

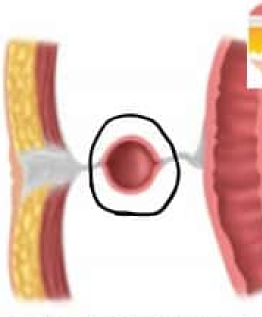


Vitelline cyst:

Ends → Fibrous cord
Center → cyst

Vitelline fistula:

Persistence of entire vitellointestinal duct
communicate between umbilicus and intestine
Faecal discharge at umbilicus

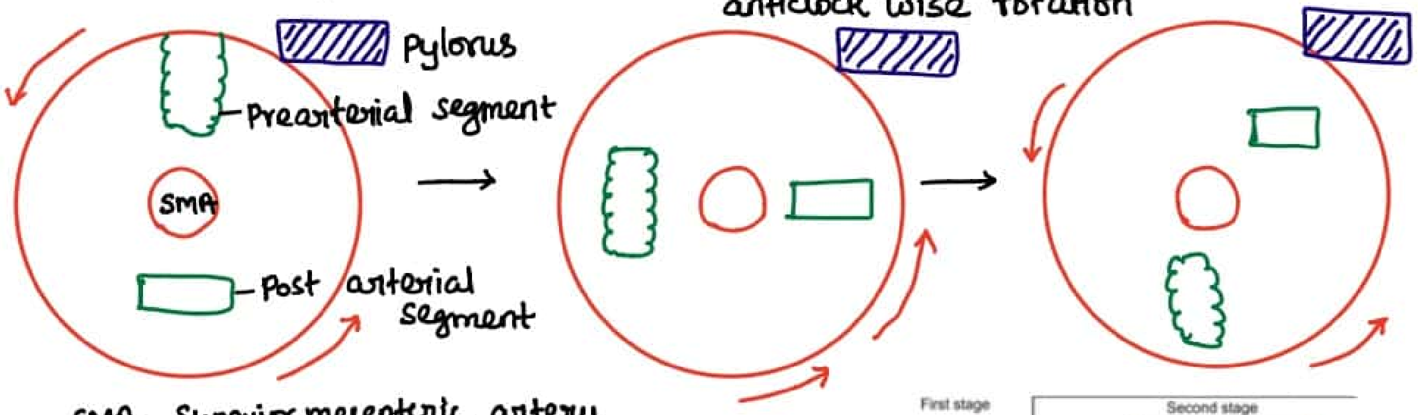

Vitelline duct cyst (enterocyst)

Rotation of MID GUT:

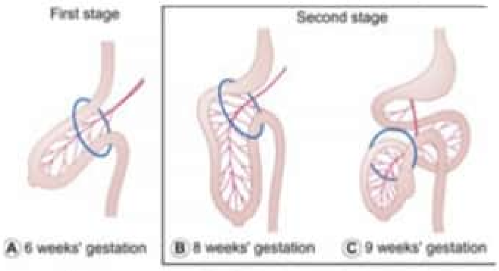
Reduction of physiological hernia → 10th week
midgut rotates 3 times → 90° couter clockwise direction
[Total 270°]

First 90° anticlock wise rotation → Right side: Pre arterial segment
Left side: post arterial segment

- Pre arterial segment → Elongates → Enters abdominal cavity and occupies left side via → second 90° anticlock wise rotation
- Post arterial segment → Enters abdominal cavity via → last 90° anticlock wise rotation

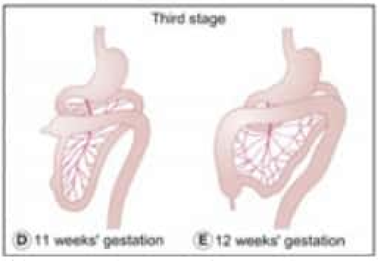


SMA- Superior mesenteric artery



Caecum located in Right upper quadrant below liver → Descends down → Right iliac fossa

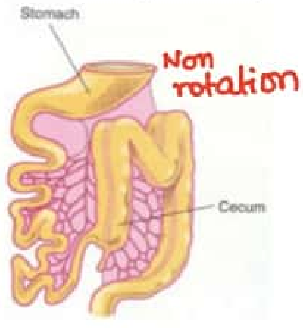
Appendix → Narrow diverticulum of caecal bud



Rotational anomalies of midgut:

1. Non rotation:

Only first 90° anti-clockwise rotation present
Large intestine - Left side
Small intestine - Right side

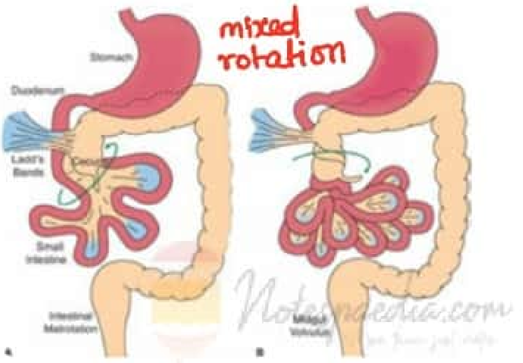


2. Mixed rotation:

First two 90° anti clockwise rotation → Normal
Last 90° rotation → Absent

Features:

1. Subpyloric caecum
2. Ladds band (extending from caecum - Posterior abdominal wall → Duodenal obstruction

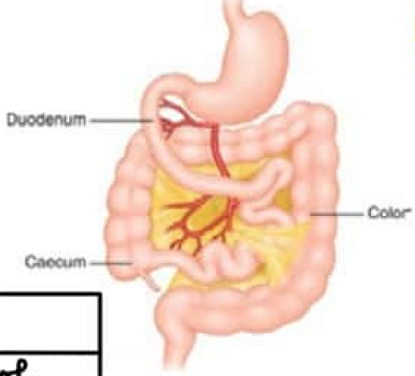


3. Reverse rotation:

First rotation → clock wise direction

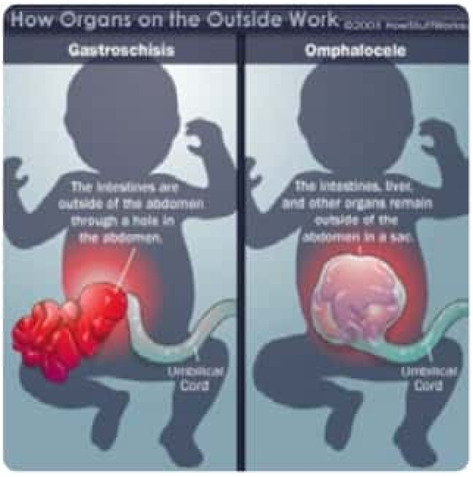
Features:

Superior mesenteric artery
Compressing Transverse colon



Omphalocele vs Gastroschisis

Omphalocele	Gastroschisis
• Failure in reduction of physiological hernia	• Hernia at the site of regression of right umbilical vein
• Sac present	• Sac present. umbilical cord position → Normal
• Liver, intestine (or any organs) remains outside the abdomen in a sac	• only intestine → Remains outside abdomen • M/c feature: Intestinal obstruction
• Associated with other congenital anomaly	• Not associated with congenital anomaly


How Organs on the Outside Work
Gastroschisis
Omphalocele
The intestines are outside of the abdomen through a hole in the abdomen.
The intestines, liver, and other organs remain outside of the abdomen in a sac.
Umbilical Cord
Umbilical Cord

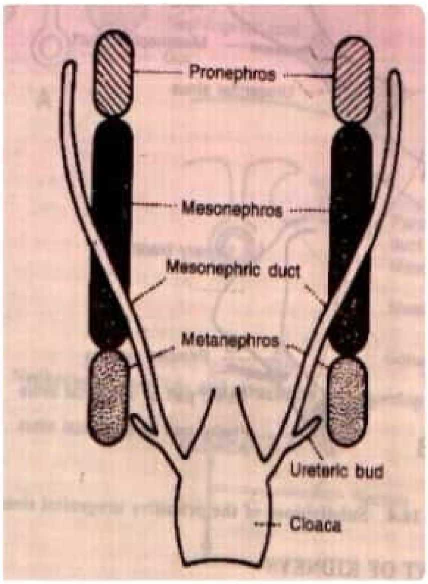
DEVELOPMENT OF HIND GUT

Development of kidney:

Pronephros:
- Formation → 4th week
- Function → Interim kidney
- Disappear → End of 4th week

Mesonephros:
- Formation → End of 4th week
- Function → Interim kidney
- Disappear → End of 2nd month

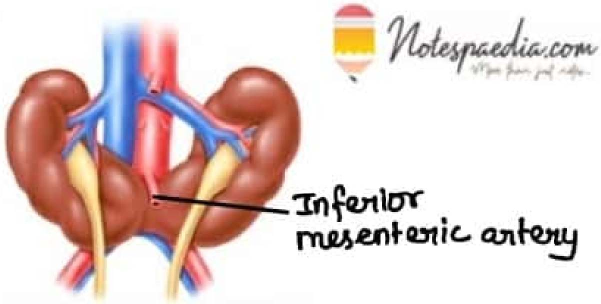
Metanephros:
- Formation → 5th week
- Starts functioning → 3rd month
- Forms : Excretory part of kidney
- Components:
  - Bowman's capsule, PCT, DCT, Henle's loop
  - Connecting tubule [Connect DCT → collecting duct]



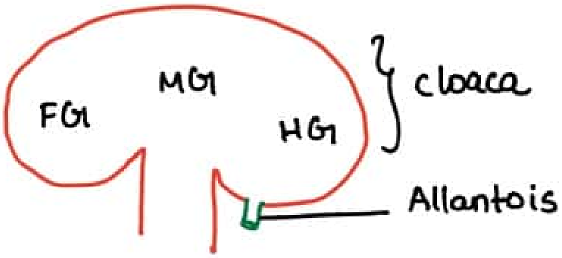
Ureteric bud:
- Derived from → mesonephric duct
- Forms : collecting part of kidney
- Components:
  - Collecting ducts, Renal calyx, Renal pelvis
  - Ureter

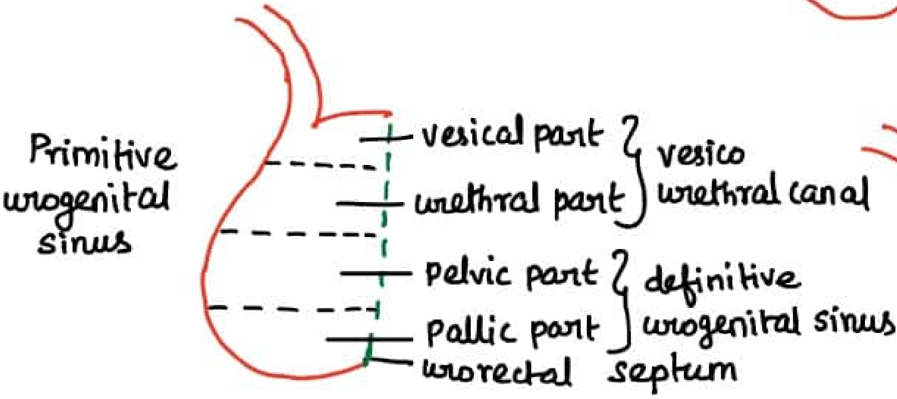
Horseshoe kidney:

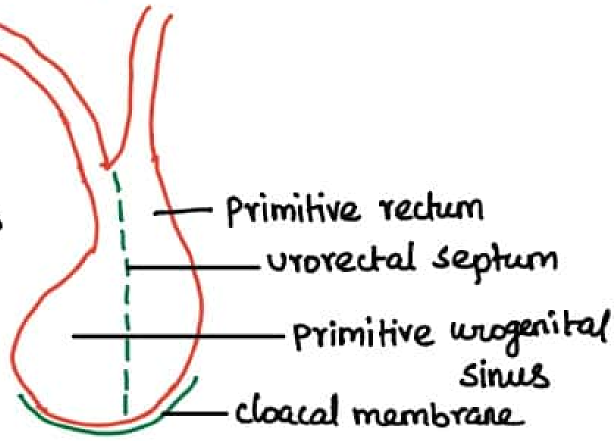
m/c developmental anomaly in kidney
Lower poles of kidney fuse
Inferior mesenteric artery
→ prevents ascend of Horseshoe shaped kidney.



Development of Hind gut:







Hindgut diverticulum → Allantois
urorectal septum divides :

cloaca
- Dorsal ↓ Primitive rectum
- Ventral ↓ urogenital sinus

Cloacal membrane
- Dorsal ↓ Anal membrane
- Ventral ↓ urogenital membrane

- primitive rectum forms:
  - Rectum
  - Anal canal up to pectinate line
- Anal membrane :
  - Location → junction of hindgut & Proctodaeum

Disappear → 9th week primitive urogenital sinus

- vesicourethral canal
  - vesicle part ↓
  - urethral part ↓
- Definitive urogenital sinus
  - Pelvic part
  - phallic part

Development of bladder, Rectum and anal canal:

Bladder:

Endodermal origin
Trigone of bladder
↓
mesodermal origin
↓ formed
Due to absorption of mesonephric duct

- Allantois forms urachus - extends from apex of the bladder to the umbilicus
- Patent urachus → urachus fistula
↓
Finding: urine at umbilicus

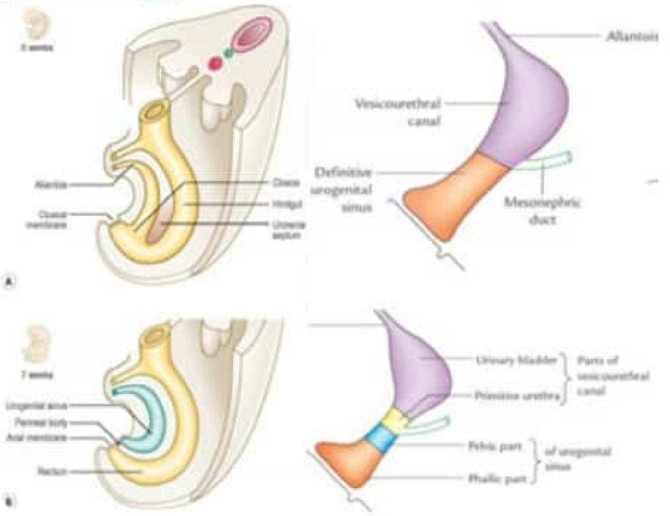
Endoderm
↓
Gut tube
↓
Hind gut
↓
Cloaca
↓
urogenital sinus
↓
vesicle part of vesicourethral canal
↓
Bladder

Rectum:

Derived from → Hind gut + Cloaca (primitive rectum)

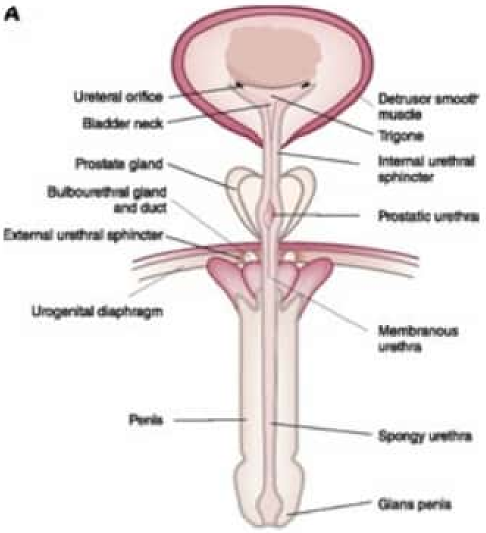
Anal canal:

Derived from → Primitive rectum (cloaca) [Endoderm]
+
Proectodeum [Ectoderm]



Development of urethra:

Development of male urethra:



Prostatic urethra

membranous urethra] pelvic part of urogenital sinus

Penile urethra] phallic part of urogenital sinus

- Prostatic urethra upto opening of ejaculatory duct → Derived from : urethral part of vesicourethral canal
- Pelvic part of urogenital sinus
  Derivatives → membranous urethra
  Part of Prostatic urethra
- Penile urethra
  Derived from → Phallic part of urogenital sinus

Development of female urethra:

- Derived from:
  - urethral part of vesicourethral canal ⊕
  - Pelvic part of definitive urogenital sinus
- phallic part of urogenital sinus forms → vestibule

DEVELOPMENT OF GONADS

Development of gonads:

Intermediate mesoderm
↓
urogenital ridge

→ Nephrogenic cord
↓
Forms: ① Kidney
② Mesonephric duct
③ Para mesonephric duct

→ Genital ridge
- Male ↓ Testis
- female ↓ ovary

- Genotype (XX/XY) determined at → Fertilization
- phenotypic differentiation → 7th week

upto 6th week → Indifferent gonad
7th week → Testis develop
10th week → ovary develop
11th week → Female external genitalia
14th week → Male external genitalia

Development of male genital system:

Testis determining factor
[SRY gene] stimulate

→ Sertoli cells ↓ Mullerian inhibiting factor

→ Leydig cells ↓ Testosterone

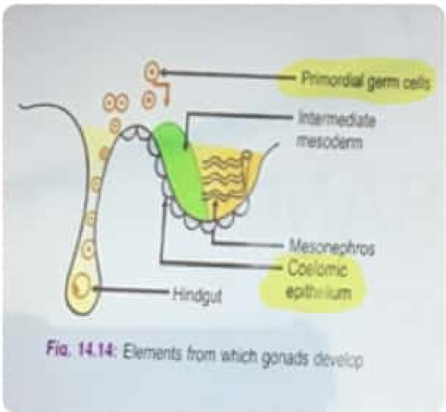


Fig. 14.14: Elements from which gonads develop

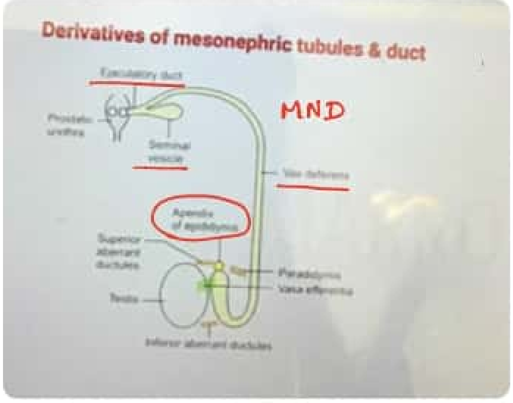
Germinal epithelium proliferates
↓
Sex cords
↓
medullary cords

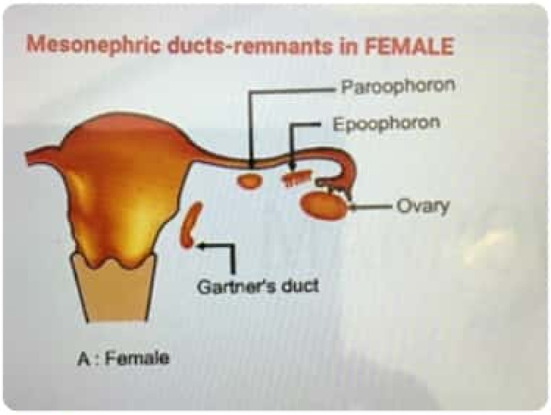
→ canalize ↓ Seminiferous

→ No canalize ↓ -Sertoli cells

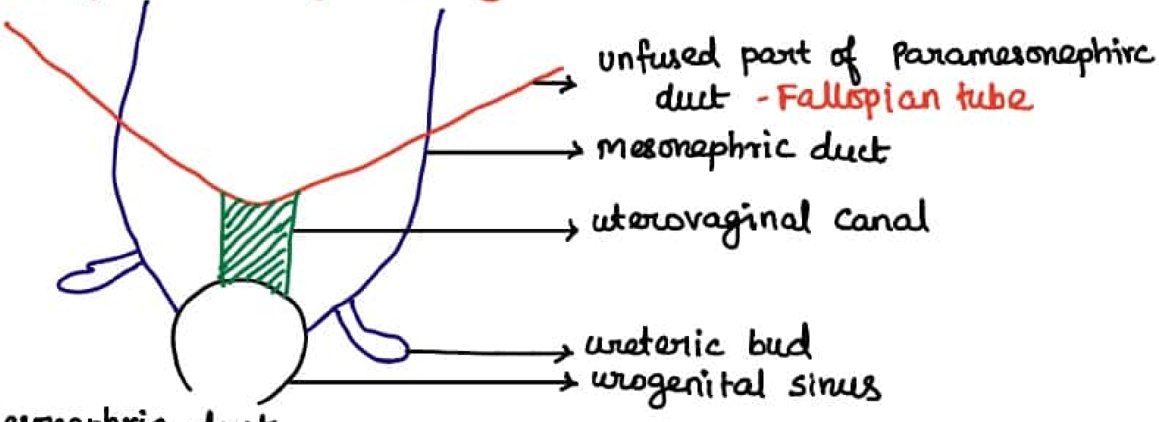
Derivatives of mesonephric & paramesonephric ducts:

Embryological Structure	Male	Female
1) Genital ridge	Testis	ovary
2) Genital tubercle	Penis	clitoris
3) Genital Swelling	scrotum	Labia majora
4) Mesonephric duct	Vas deference, epididymis, seminal vesicles, Ejaculatory duct, appendix of epididymis	Appendix of ovary Gartners duct
5) paramesonephric duct	Appendix of testis, prostatic utricle	Fallopian tube, uterus vagina
6) Mesonephros	Aberrant tubules/ Efferent tubules	Epoophoron, paroophoron.


Derivatives of mesonephric tubules & duct


Mesonephric ducts-remnants in FEMALE

Development of female genital system:



Paramesonephric duct

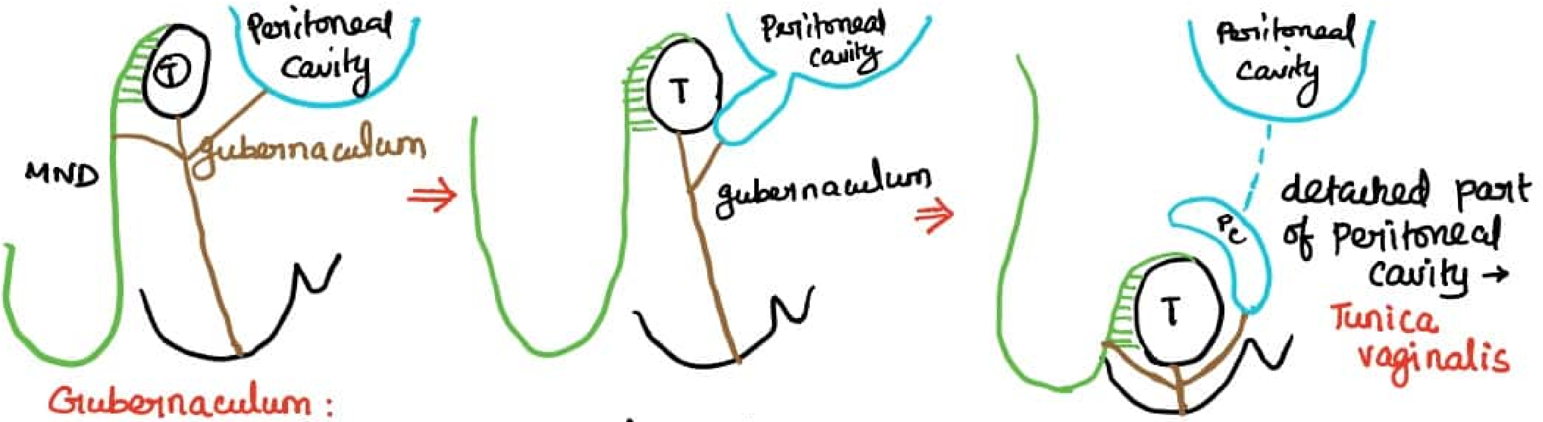
Unfused Part
↓
Fallopian tube

Fused Part
↓
- uterus
- upper Part of vagina

→ vagina :

1. upper 2/3rd → uterovaginal canal (mesoderm of Paramesonephric duct)
2. lower 1/3rd → urogenital sinus [endoderm]

Descent of testis :



Gubernaculum :

- Extend from lower pole of testis to scrotum
- Upper end attached to peritoneal cavity and mesonephric duct

Relative shortening of gubernaculum:

↓

Testis, peritoneal cavity, mesonephric duct → Descends into scrotum

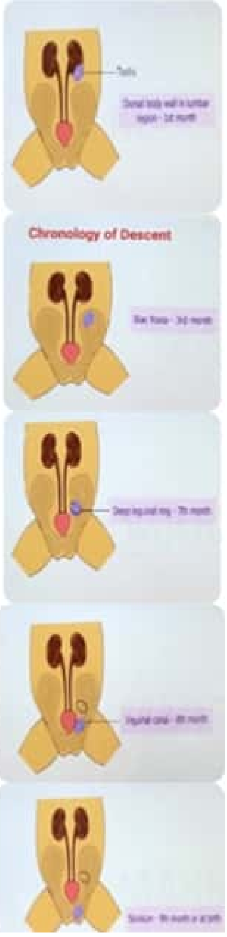
↓

Peritoneal cavity detaches from gubernaculum

↓ Forms

Tunica vaginalis

Chronology of descent:


Testis
Dorsal body wall in lumbar region - 1st month
Chronology of Descent
Iliac fossa - 3rd month
Deep inguinal ring - 7th month
Inguinal canal - 8th month
Scrotum - 9th month or at birth

1st month
Testis located in dorsal body wall in lumbar region

↓

3rd month
Testis reaches iliac fossa

↓

7th month
Deep inguinal ring

↓

8th month
Inguinal canal

↓

9th month [or at birth]

- Gubernaculum in female
  - Proximal part → Ligament of ovary
  - Distal part → Round ligament of uterus

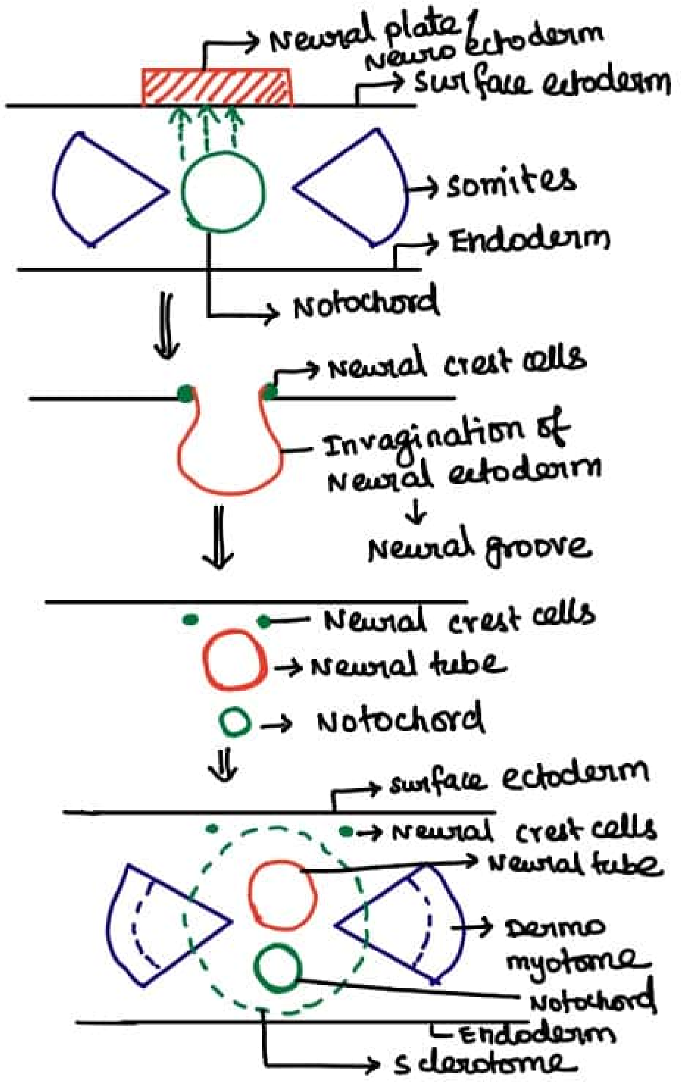
DEVELOPMENT OF CNS

Neurulation:

Process of development of Neural tube occurs in 3rd week

Notochord
↓
Gives signal to Ectoderm
↓
Forms a Neural plate
↓
Now Ectoderm → Surface ectoderm ; → Neuro ectoderm

Neuro ectoderm
↓
Invaginates and forms Neural groove
↓
Neural tube



Neural crest cells:

2° mesenchyme
4th germ layer

Somites → sclerotomes ; → Dermomyotomes

sclerotomes
↓
Surrounds both Neural tube and Notochord
↓
Forms dorsal, ventral and lateral somites

- Neural tube formation initially occurs in cervical region

↓

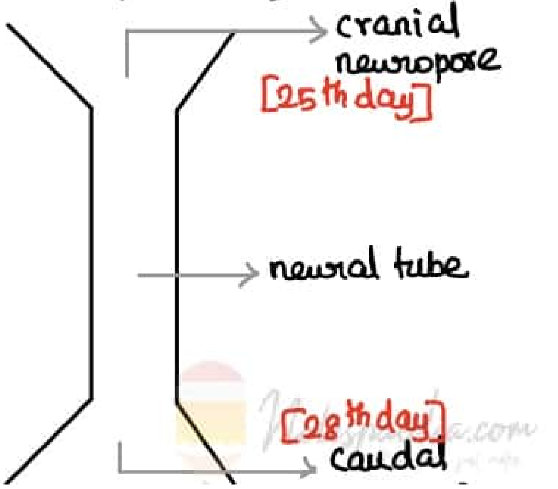
upper and lower end of neural tube is communicating with the Amniotic cavity through anterior and posterior neuropore (or) cranial and caudal neuropore

↓

Cranial Neuropore closes by 25th day
Caudal Neuropore closes by 28th day

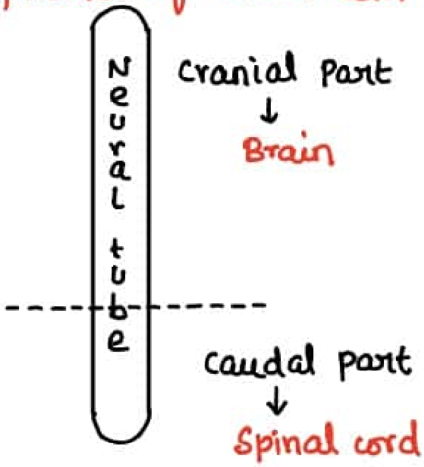
↓

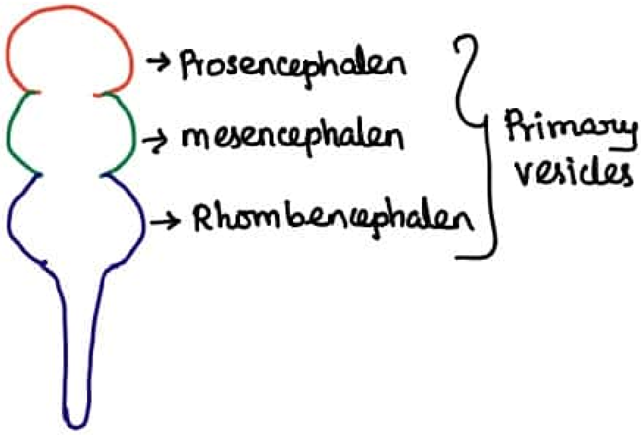
Failure of closure of cranial neuropore } Anencephaly
Failure of closure of caudal neuropore → Rachischisis
} Neural tube defects

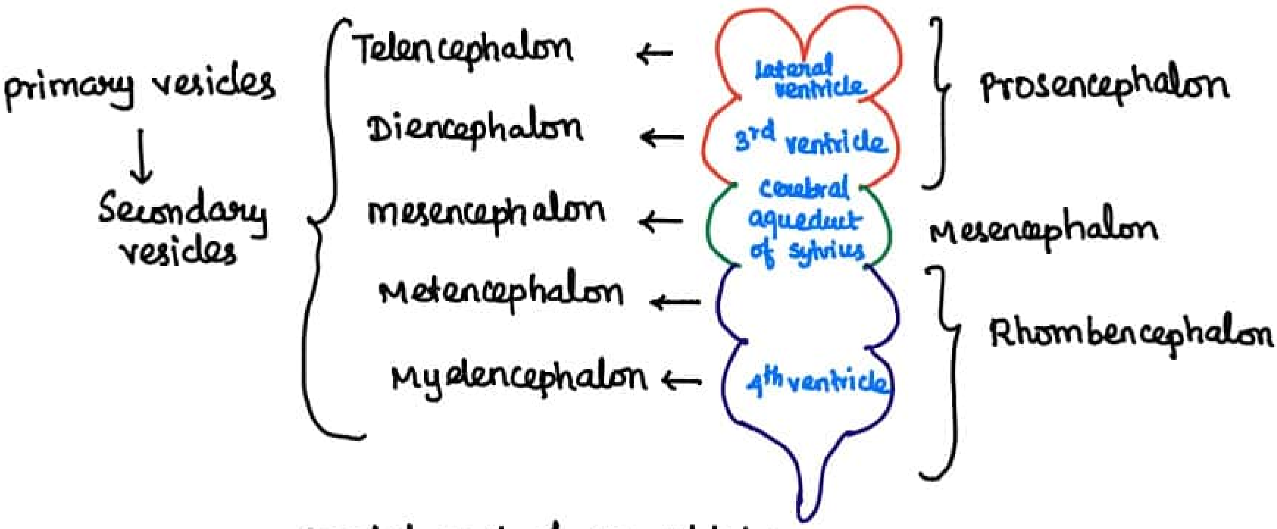


- Remnant of cranial neuropore → Lamina terminalis
- Remnant of caudal neuropore → Terminal ventricle
- Neural tube defects are due to deficiency of folic acid. So, folic acid is given to mothers from first trimester as neural tube is formed from 3rd week

Development of brain and spinal cord:







Cranial part of Neural tube
↓
Primary vesicles of brain

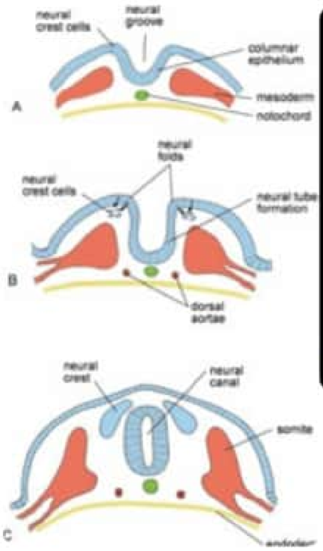
- prosencephalon
  - Telencephalon ↓
    - cerebral cortex
    - corpus striatum
  - Diencephalon ↓
    - Thalamus
    - Hypothalamus
    - Metathalamus
    - Subthalamus
    - Epithalamus
    - Pars nervosa
    - Optic stalk
- mesencephalon ↓
  - Midbrain
- Rhombencephalon
  - Metencephalon ↓
    - Pons and cerebellum
  - myelencephalon ↓
    - medulla

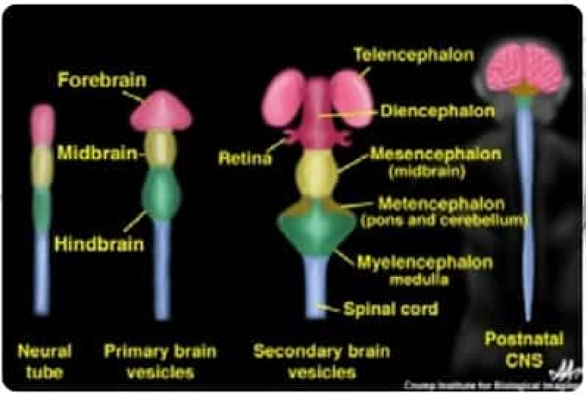
Cavities inside brain [ventricles]

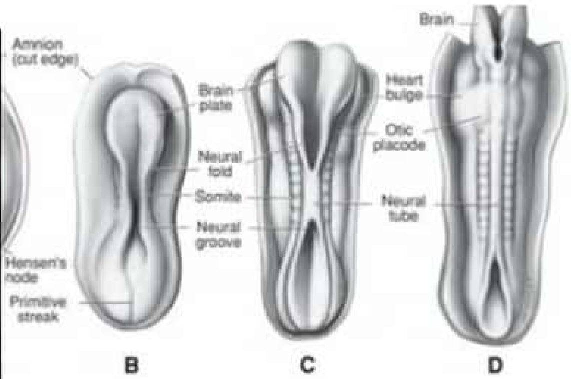
- Telencephalon → Lateral ventricle
- Diencephalon → 3rd ventricle
- mesencephalon → Cerebral aqueduct of sylvius
- meten and myelencephalon → 4th ventricle

Note:

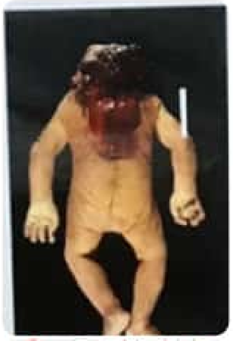
corpus striatum - Telencephalon
Substantia Nigra - mesencephalon / midbrain
Sub thalamus - Diencephalon
Medial and lateral geniculate bodies → metathalamus → Diencephalon
pineal gland → Epithalamus → Diencephalon





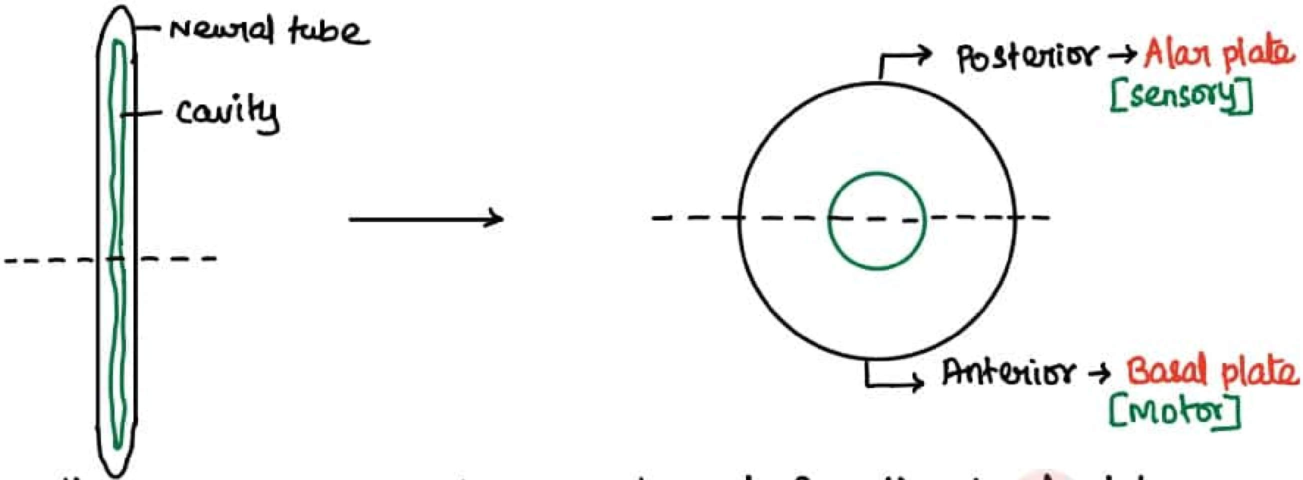


Craniorachischisis:
Severe form of Neural tube defect


Craniorachischisis

2016 ♀ AIIMS

FUNCTIONAL COLUMNS OF CRANIAL NERVE NUCLEI


Neural tube
cavity
Posterior → Alar plate [sensory]
Anterior → Basal plate [Motor]

All the motor; components are derived from the basal plate
eg. Hypoglossal Nucleus (AIIMS & PGI)

All the sensory components are derived from the alar plate
eg. vestibular Nucleus (AIIMS & PGI)

Functional columns:

- Functional columns
  - Efferent
    - General somatic efferent
    - Special visceral efferent
    - General visceral efferent
  - Afferent
    - General somatic afferent
    - Special visceral afferent
    - General visceral afferent
    - Special somatic afferent

a. General Somatic efferent :

Efferent - motor

- muscles derived from somites
  - occipital somites
    - Muscles of Tongue - 12th cranial nerve (CN)
  - pre occipital somites
    - Extra ocular muscles - 3,4,6 CN's

- 3,4,6 and 12 cranial nerve Nuclei → General somatic Efferent

b. Special visceral Efferent:

Carries motor fibers to pharyngeal arch derivatives

I - mandibular nerve → motor nucleus of 5th nerve
II - Facial nerve → motor nucleus of 5th nerve
III - Glossopharyngeal nerve (9th) →
IV - superior laryngeal nerve (10th) → } Nucleus ambiguous
VI - Recurrent laryngeal nerve (10th) →

Nucleus Ambiguus - contain's 9,10 cranial nerve nuclei >> 9,10,11

C. General visceral Efferent:

Parasympathetic column - carries Secretomotor fibers
parotid, submandibular, sublingual, lacrimal, nasal & Palatal glands:

Parotid glands:

Inferior Salivatory nucleus (in pons) $\xrightarrow{\text{9th nerve}}$ relay in OTIC ganglion → Parotid gland

9th nerve - pre ganglionic parasympathetic → otic ganglion → parotid fibres

Submandibular and sublingual glands:

Superior Salivatory Nucleus (in pons) $\xrightarrow{\text{7th nerve}}$ relay in submandibular ganglion
↓
Submandibular & sublingual glands

Lacrimal, Nasal, Palatal glands:

Lacrimatory nucleus
[caudal part of superior Salivatory Nucleus] $\xrightarrow{7^{th}\ nerve}$ pterygopalatine ganglion → Lacrimal, Nasal, palatal glands

7th nerve carries preganglionic Parasympathetic fibers

Edinger westphal Nucleus $\xrightarrow{3^{rd}\ nerve}$ ciliary ganglion → sphincter pupillae and ciliaris muscles

Dorsal nucleus of vagus - parasympathetic nucleus for vagus nerve(X)
Para Sympathetic nerves involved in general visceral efferent - 3, 7, 9, 10

Afferent columns:

Special visceral Afferent (SVA)
General visceral Afferent (GVA)
} Nucleus tractus solitorius [General + Taste sensation]

Special visceral Afferent:
Anterior 2/3rd of tongue - 7th nerve
Posterior 1/3rd of tongue - 9th nerve
posterior most part of tongue - 10th nerve
} taste pathway nerves

General Somatic Afferent: [GSA]

General sensations from the body
Mesencephalic nucleus
Chief Sensory nucleus
Spinal nucleus
} Trigeminal nerve

Trigeminal nucleus	Location
Mesencephalic nucleus	Midbrain [for proprioception]
chief sensory nucleus	Pons
spinal nucleus	Medulla, spinal cord upto C_1, C_2

Total number of trigeminal Nuclei - 4
- 3 in GSA
- 1 in SVE

Special Somatic Afferent: [SSA]
- ventral nucleus
- cochlear nucleus

HISTOLOGY

Epithelium :

1. Simple epithelium
   unilayer
   - i) Simple squamous
   - ii) Simple cuboidal
   - iii) Simple columnar

2. Compound epithelium
   Many layers (stratified)
   - i) Stratified squamous
   - ii) Stratified cuboidal
   - iii) Stratified columnar

3. Transitional epithelium.

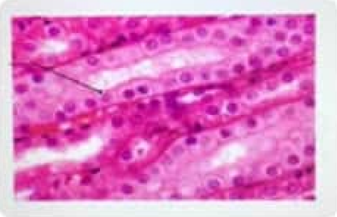
Simple squamous epithelium:

Breadth > length
Nucleus flat

"exchange function"

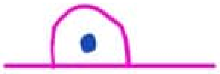
eg. mnemonic 3B A
B - Blood vessel
B - Body cavity
B - Bowmans capsule
A - Alveoli

Simple cuboidal epithelium:



Simple cuboidal epithelium

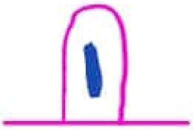
Length = Breadth
Round Nucleus

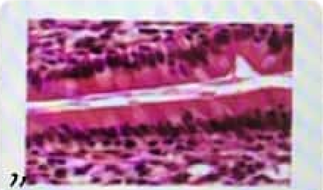


eg. T-O-K
Thyroid follicles
Germinal epithelium of ovary
Tubules of kidney

Simple columnar epithelium:

Length > breadth
elongated nucleus





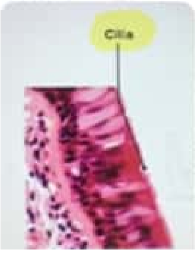
Simple columnar epithelium

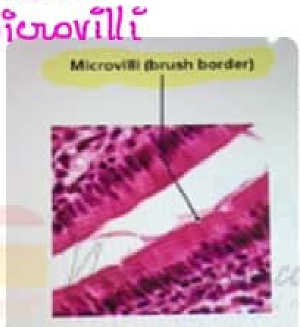
eg. stomach, large intestine, uterus "Secretory function"

Note: Surface projection's : cilia/microvilli (Brush border)
↓
↑ Surface area

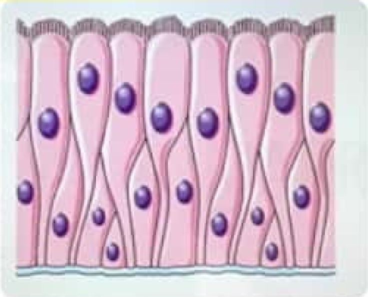
i) microvilli
eg. Small intestine – Simple columnar with microvilli
Gall bladder – Simple columnar with microvilli

ii) Cilia :
a motile structure
Simple columnar with cilia:
eg. Fallopian tube
Eusthachian tube
Middle ear
Ventricles of brain





Pseudo Stratified Ciliated columnar epithelium:

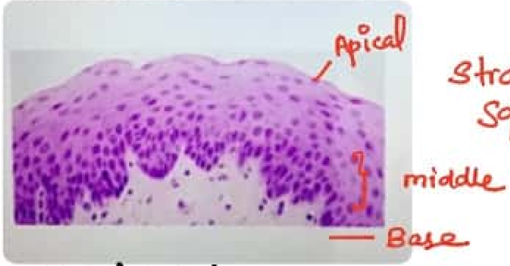


Simple epithelium
- Nucleus arranged in various layer's
Seen in trachea, bronchus

Stratified epithelium:

Stratified Squamous epithelium:

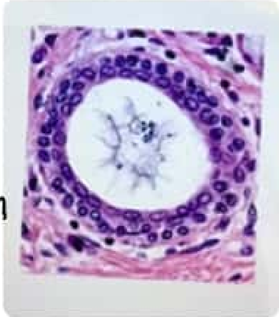
many layer's
Basal layer - columnar
Middle - Polyhedral
Apical - squamous
Present in ⇒ skin, lips, tongue
Tonsil, esophagus, vagina, vocal card
Function ⇒ Barrier



Stratified Squamous epithelium

Stratified Cuboidal epithelium:

Seen in ducts of exocrine glands and sweat glands
except : Sebaceous gland ⇒ It is lined by Str. squamous epithelium

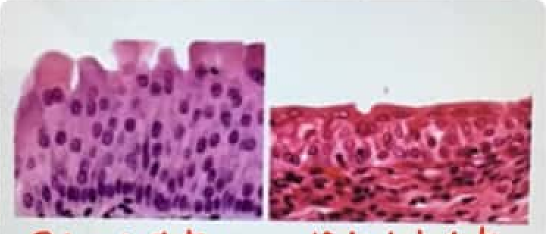


Stratified Columnar epithelium:

Present in membranous & penile urethra
This is lined by stratified columnar (or) pseudostratified columnar epithelium

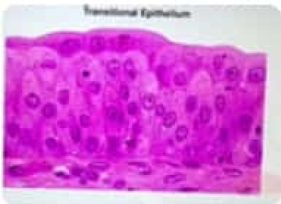
Transitional Epithelium

able to change one shape to another
Seen in urinary system ⇒ urothelium



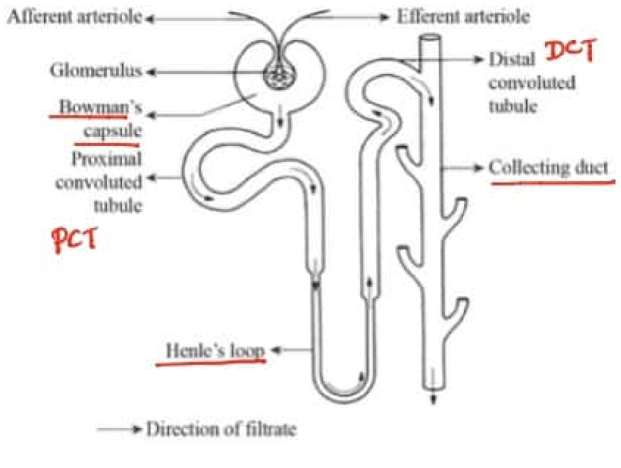
Relaxed state distended state

Stratified Squamous epithelium	Transitional epithelium
i) many layers	many layers
ii) middle layer - Polygonal	Middle layer - Polygonal
iii) Apical → squamous flat nucleus	Apical — umbrella shaped cells
iv) Desmosomes – absent	Present



Transitional epithelium + star

Nephron: (lining epithelium of different part of Nephron)

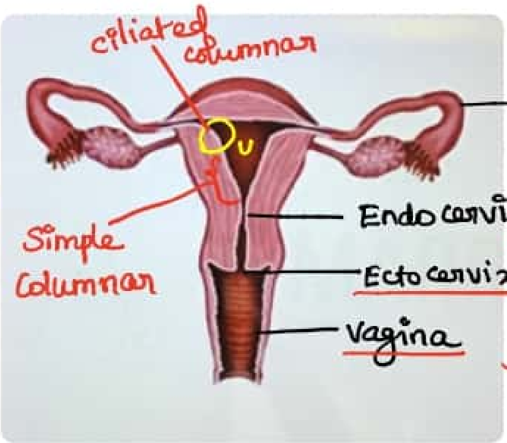


Different parts of the nephron

Bowmans capsule - Simple squamous
Proximal convoluted tubule - Simple cuboidal with microvilli
Thick ascending & descending limb - Simple cuboidal
Thin ascending & descending limb - Simple squamous with microvilli
Henle's loop - both simple squamous & cuboid
Collecting duct - Simple cuboidal & Simple columnar

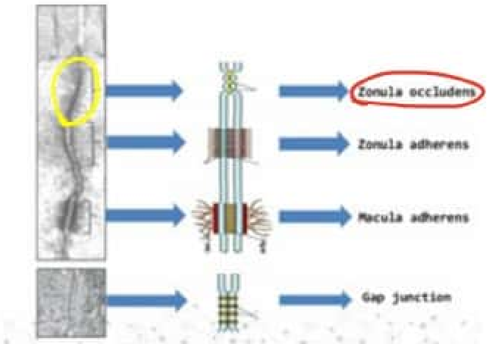
Female Genital System

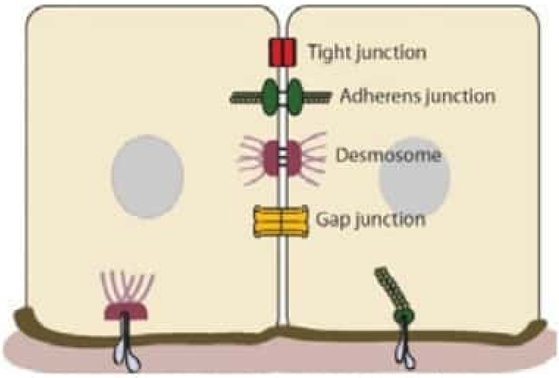
uterus is lined by
Simple columnar >
ciliated columnar



Junctional Complex: connection b/w adjacent cells

2018 Nov
♀





a) Tight Junction:

Barrier function
Prevent barrier of
Substance one cell to another

b) Anchoring Junction:

Link - adjacent cell together
Cells function as Single unit
Macula adheren's - Desmosomes
link - intermediate filaments
Cadherins as adherent molecules
Zonula adherens - link - actin

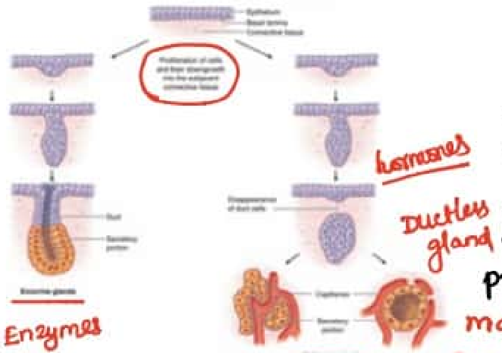
Note: Pemphigus Vulgaris:
Autoantibodies against catherin's

c) Gap Junction:

gap b/w 2 cells
Action potential, organelles passing through one cell to another
Intercalated disc: (cardiac muscle)
Contain: Gap Junction, Zonula adherens
macula adherens

GLANDS

Formation of glands from covering epithelium



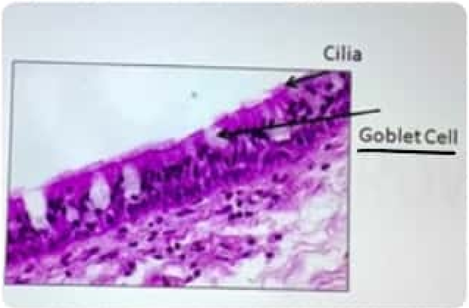
Glands - epithelium with secretory function

↓

Invaginate into connective tissue

- Forms 2 Parts
  - proximal
    - maintain Connectivity c̄ Surface epithelium
  - distal
    - maintain secretory function (Exocrine glands)
    - Duct - ⊕
    - Realeses enzymes
- Forms 2 Parts
  - Proximal
    - ↓ disappears
  - distal
    - ↓ persists
    - ⇓ Endocrine glands
    - Duct ⊖
    - Realeses hormones directly to the blood Stream

Exocrine glands:



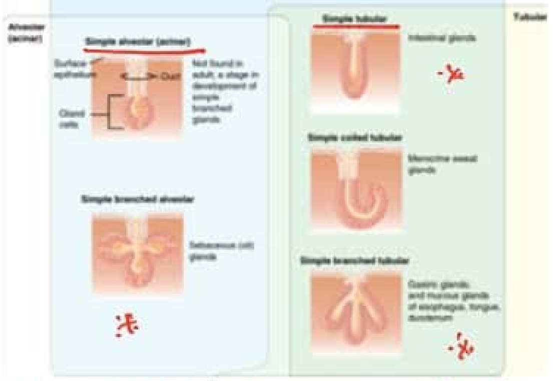
Exocrine glands

- unicellular
  - Goblet cell
  - Exocytosis
  - mucin secretion
  - H & E stain - Pale
- multicellular

Simple exocrine glands

unbranched gland

Secretion's → Single duct



Compound exocrine glands

branched glands

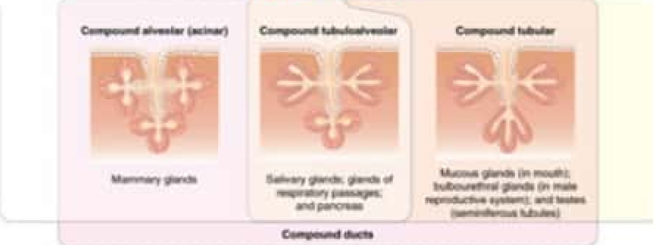
group of secretory cells

↓

own duct

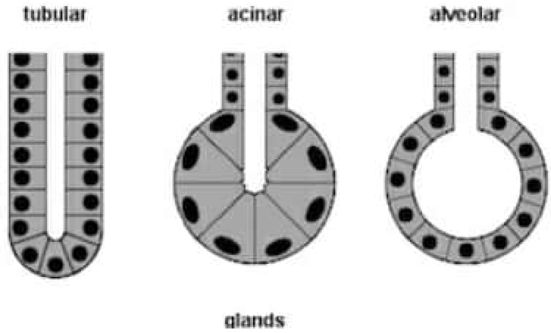
↓

" main duct "


Compound alveolar (acinar)
Mammary glands
Compound tubuloalveolar
Salivary glands; glands of respiratory passages; and pancreas
Compound tubular
Mucous glands (in mouth); bulbourethral glands (in male reproductive system); and testes (seminiferous tubules)
Compound ducts

Based on Secretory part, glands

- Tubular
- Acinar
- Alveolar



eg: Simple gland

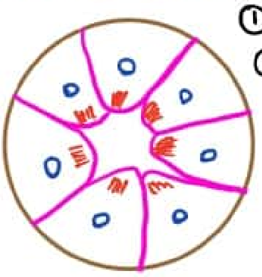
- Simple tubular
  - Intestinal glands
- Simple coiled tubular
  - Sebaceous glands
  - merocrine glands
- Simple branched tubular
  - Gastric glands

Compound glands:

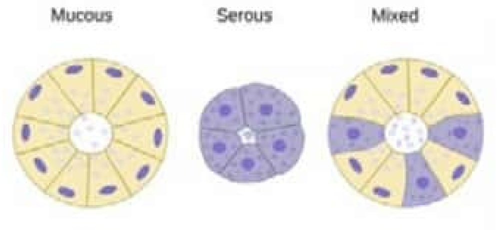
- Compound alveolar
  - mammary glands
- Compound tubular alveolar
  - Salivary glands
  - Respiratory passage
- Compound tubular
  - mucous gland
  - Bulbourethral

Based on type of secretion's :

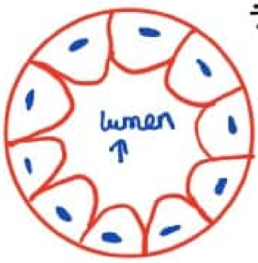
Serous Acini :



① secretory cells - pyramidal shape
② central spherical nucleus
③ apical eosinophilia
④ lumen - ↓ size

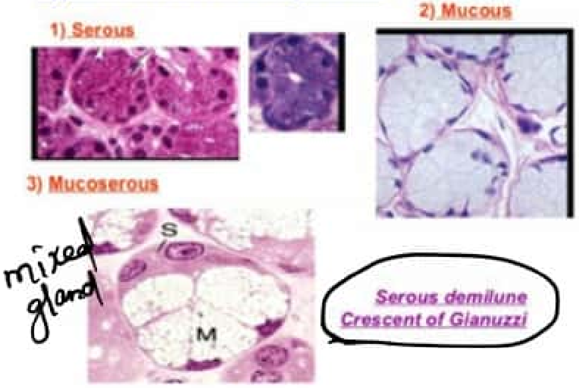


Mucous :



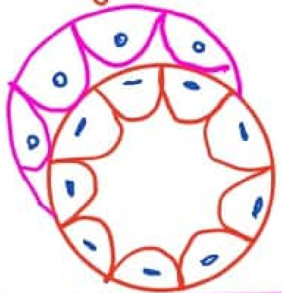
⇒ secretory cells - cuboidal/ columnar
⇒ mucin secretion
⇒ flattened nucleus - Base of gland
⇒ H & E stain - pale

Types of Acini in Salivary Glands



mixed gland

Mixed gland :



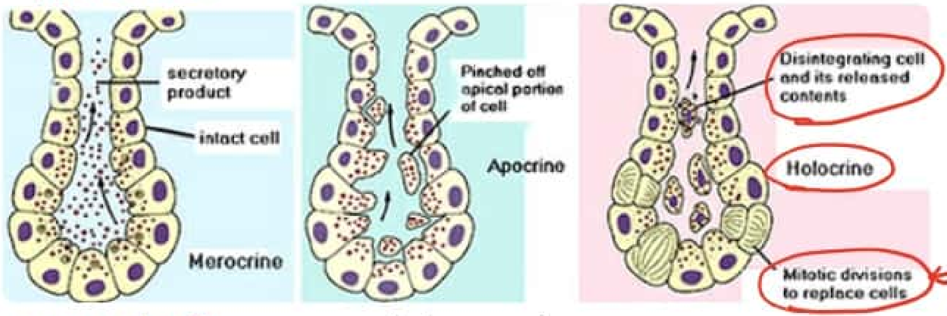
Serous demilunes
⇓
mucous gland capped with serous acini
Function - ↓ the consistency of mucus

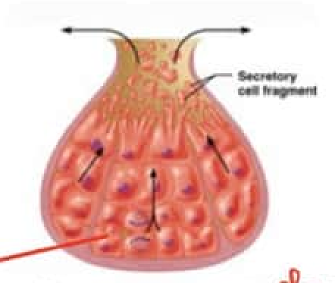
Serous gland - Parotid gland
Mucus gland - Sublingual
Mixed gland - Submandibular

More than just notes

Based on mode of secretion :

Merocrine | Apocrine | Holocrine


secretory product
intact cell
Merocrine
Pinched off apical portion of cell
Apocrine
Disintegrating cell and its released contents
Holocrine
Mitotic divisions to replace cells



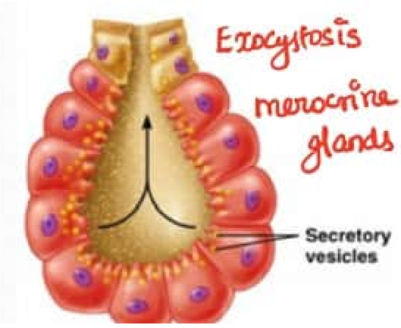
Sebaceous gland

- exocytosis
- Intact cell

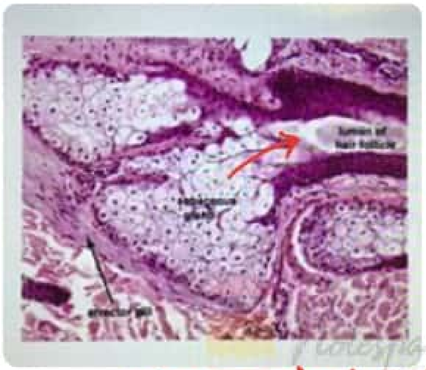
eg. sweat glands & salivary glands

secretory granules
→ Apex pinched off
eg.
M - mammary gland
A - Axilla } atypical
P - Pubis } sweat glands

eg. Sebaceous gland



Exocytosis
merocrine glands



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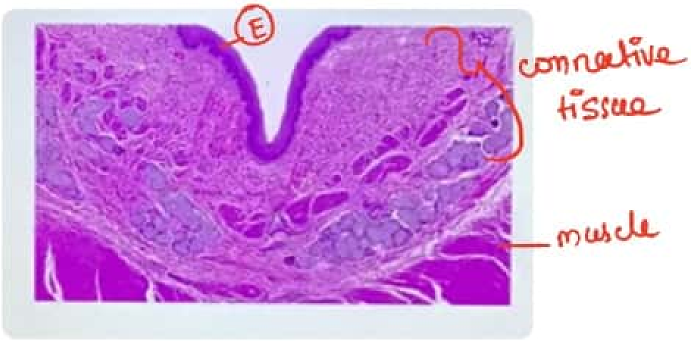
Sabaceous gland (holocrine

Connective Tissue

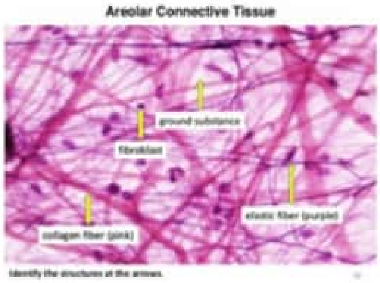


Function of connective tissue:
① hold the structure together
② Support to the structures

Connective tissue
- General tissue
  - cells + matrix (fibers + ground substance)
- Special connective tissue

Collagen Fibers:

Long fibers
found in bundles - straight / wavy manner


Areolar Connective Tissue

Identify the structures at the arrows.

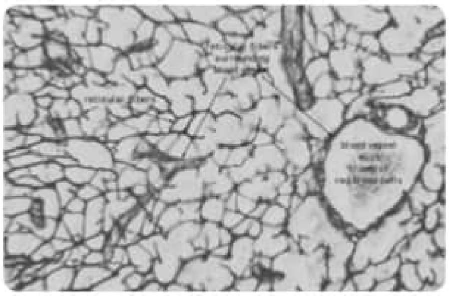
Staining properties:
white - naked eye
light pink - H & E stain

Special stain's:
masson's trichrome - Blue
Van Gieson's - Pink
Silver impregnation - Brown

Type of collagen fibers:
Type 1 - Bones, ligaments, Tendon's, aponeurosis, fascia, Fibrous Cartilage
Type 2 - Hyaline & elastic Cartilage
Type 3 - Reticular fiber's - lymphoid organs (except Thymus)
Type 4 - Lens capsule & Basement membrane

Reticular fibers:

Subtype of collagen fiber's
Not arranged in bundles
Short, thin fiber's
Branch - anastamose - Reticulum - network



Staining Properties:
Argentaphil (love)
"Ag" silver impregnation - Black

Elastic fibers

Not arranged in bundles
Short, Not wavy manner
Short & thin fibers

Some Cases elastic fibers will be thick
eg. Ligamentum flavum ♀ 2018 Nov AIIMS

Special stain's:
orcein stain
Aldehyde fuchsin
Verhoeff's stain

Cells:

⇒ Intrinsic component of connective tissue
- Fibroblast
- Pigment cells
- fat cells

- undifferentive mesenchymal cells

→ cells - Immune System : macrophage, mast cells, lymphocyte, monocyte, esinophil

Fibroblast :

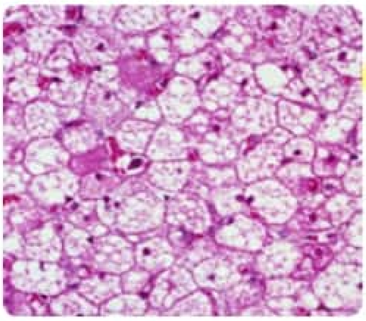
- numerous in number
- Produces collagen fibers
- also called as reticulocyte produce reticular fibers
- Found close to collagen fibers
- Fixed - immobile
- H & E stain :
  Spindle - flat nucleus
- Fibrocyte - Inactive fibroblast

Adipose Tissue

- Aggregation of fat cells
- large quantity of fat - occupy entire cell
- X lene / Benzene solvent's dissolves fat in the cell - Empty cell
- Nucleus pushed to periphery
  - Flat neucleus
- Special stain's used for fat cells :
  Sudan III / IV

Brown Adipose Tissue :

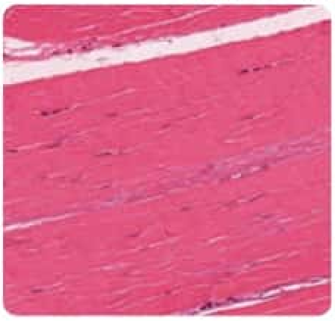
- Abundant in newborn
- Brown colour
- Multilocular - fat occurs in the form of multiple droplets
- Nucleus - Central, Spherical



Brown Adipose tissue

Connective tissue - Arrangement of fibers:

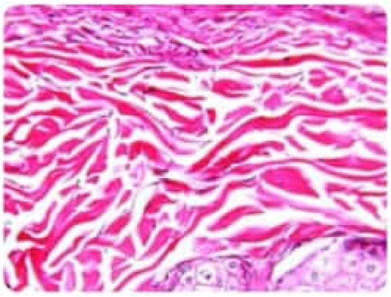
Dense regular



Fibers are arranged in regular Pattern

eg. A - Aponeurosis
L - Ligaments
T - Tendon's

Dense irregular



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Fibers arranged in irregular Pattern

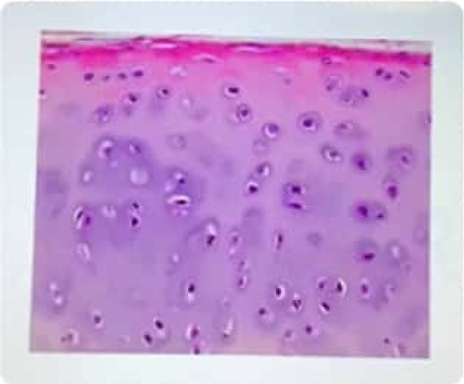
eg. Dermis of the skin
organ capsules.

CARTILAGE

Cartilage → special type of connective tissue

* cells - chondrocyte
* matrix - Fibers, Connective tissue

Hyaline Cartilage :

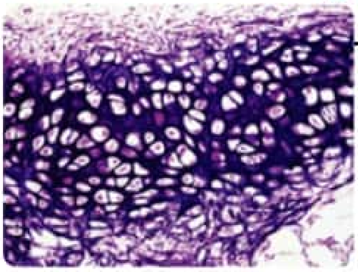


- chondrocytes arranged in group's
- matrix - Shiny
  Refractive fibre of the fibre is same as that of ground substance
- Type II collagen fibers
- Perichondrium ⊕
  2 layer - outer fibrous layer
  Inner Chondrogenic layer

eg. (ACE inhibitor's available in Eemergency Room)

A - Articular cartilage
C - Costal cartilage
E - Epiphyseal cartilage
E - Embryonic cartilage
R - Respiratory cartilage

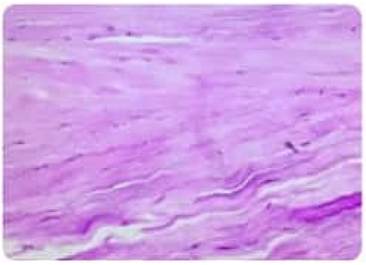
Elastic Cartilage :



- Chondrocytes arranged in group
- matrix - elastic fibers visible using Special Stain
- Type II collagen fibers
- perichondrium - present

eg. Mnemonic EEE
E - Eustachian tube
E - Epiglottis
E - Ear lobe
Apex of arytenoid
Corniculate
Cuneiform

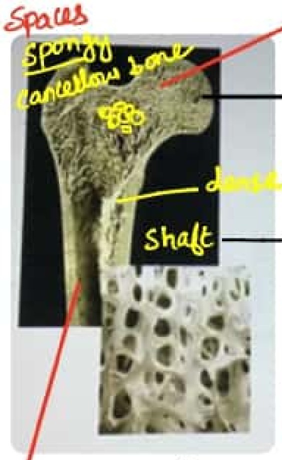
Fibrous Cartilage :



- Chondrocyte arranged in rows
- matrix - numerous Collagen bundles
- Type I collagen
- perichondrium - absent

eg. mnemonic MAGI
M - menisci
A - Articular disc
G - Glenoid labrum
I - Intervertebral disc

BONES



marrow cavity - not extending - numerous tiny spaces
Epiphysis
dense - uniform texture c̄out any space
diaphysis - marrow cavity
Compact bone

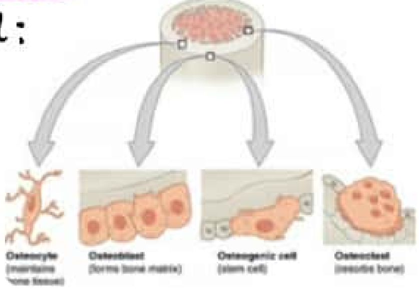
Note : Compact bone - diaphysis
Cancellous bone - Epiphysis

Marrow Cavity & Spaces in Cancellous Bone filled with Bone marrow

Red BM	yellow BM
Epiphysis (end)	Diaphysis (shaft)
Numerous blood vessels	fat
Hematopoitic stem cells	

Note : Bone of fetus / young child - Entire bone marrow
Red BM - gradullay change yellow BM

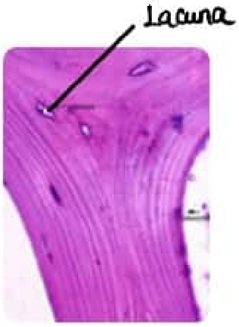
Bone Cells :

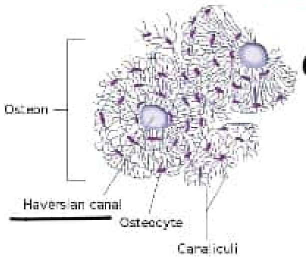

Osteocyte (maintains bone tissue)
Osteoblast (forms bone matrix)
Osteogenic cell (stem cell)
Osteoclast (resorbs bone)

① Osteogenic progenitor cell :
mesenchymal stem cell
↓
osteoblast

② Osteoblast :
derived from osteogenic progenitor cell
Bone forming cells
Forms bone matrix

③ Osteocytes :
cells of mature bone
Located in lacuna
Numerous canaliculi Can be located





Canaliculi :
- Forms Lacuna, canaliculi → arises from various direction's
- The canaliculi in turn join's with other Canaliculi of the neighbouring lacunae
- contain's processus from the osteocyte

④ Osteoblast :
Resorbs the bone

Organic & Inorganic Constituent's - Bone matrix :

Organic constituent's	Inorganic constituent's
Dense bundle of collagen fibers embedded in the ground Substance	Calcium hydroxyapatite
Osteoid - collagen + ground Substance	Rigidity

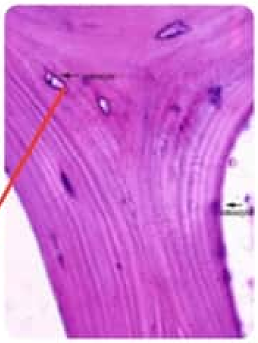
Lamellar Bone :

Bone made of many layers - lamellae

lamellus - thin bony plate

calcium & collagen fibers are deposited in the ground Substance

Space b/w lamellae ⇒ Lacunae



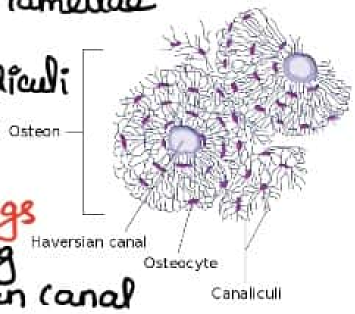
Compact Bone :

Bone made of lamellae

lamellus - has lacunae & canaliculi

Lamellae - arranged in concentric rings

Center of the Ring - Haversian canal



Blood vessels & Nerves Pass through Haversian Canal

Osteon → Haversian canal + lamellus

Volkmann's Canal → canal which connect 1 haversian Canal with the other or with bone marrow

Cancellous Bone :

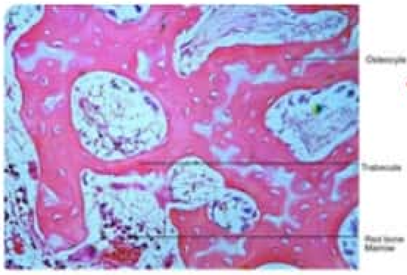
- Haversian System - Absent
- Bone is arranged in the form of trabeculae

Red bone marrow → present in the intertrabecular Space

Osteocytes - seen in the lacunae

Lacunae - Seen in the trabeculae

margins of trabeculae → numerous Osteoblast & Osteoclast



Cancellous (Spongy) Bone (400x)

	Compact bone	Cancellous bone
Site	Diaphysis	Epiphysis
Bone marrow	Yellow	Red
pattern of arrangement	Haversian System ⊕	Trabecular arrangement
Consistency	Hard, ivory like	spongy like

Muscles

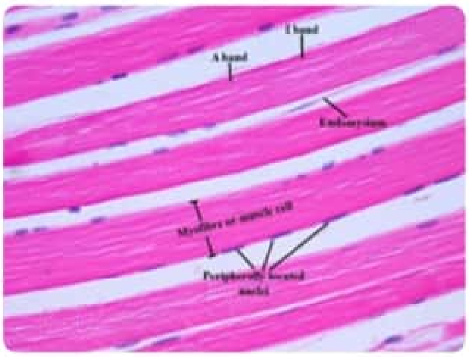
made of myocyte - elongated in particular direction → "muscle fiber"

muscle fibers are enclosed by connective tissue

Connective tissue → provides passage for blood vessels, nerves.

Skeletal	Smooth	Cardiac
i) Found in close relationship with Skeletal System	Found in the hollow visceral organs	Found in the heart
ii) Predominant feature - striation's	No striation's	Striation's - Present
iii) voluntary muscle	Involuntary muscle	Involuntary muscle
iv) Supplied by Somatic nerve	Supplied by ANS (autonomic nervous system)	Supplied by ANS

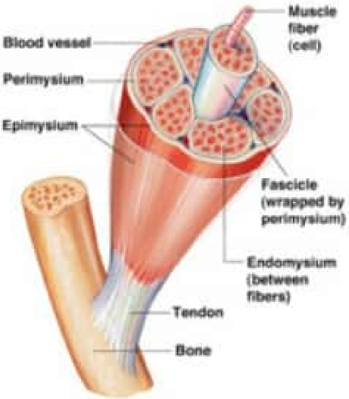
Skeletal Muscle:



i) made of long, cylindrical fibers
ii) Fibers → Run parallel to each other
iii) length & Diameter → varies from fibre to fibre
iv) Syncytium → Formed by fusion of cells
cytoplasmic mass containing numerous nuclei
v) Each muscle fibre → acts as a single syncytium with hundreds of nuclei along the wall
vi) Nucleus → Flat & found in periphery
vii) Striations → On H & E (hematoxylin & Eosin stain)

A-band
Dark band
H-band → light band in the centre of A-band

I-band
Light band
z-band - Dark line in the centre of I-band

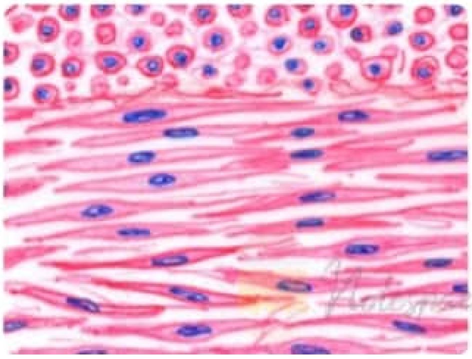


viii) Sarcomere [2016 Nov AIIMS] → a part of myofibril b/w 2 adjacent Z bands
ix) Endomysium → covering of each muscle fibre
x) Fascicle → Aggregation of muscle fibre
xi) Perimysium → covering of each fascicle
xii) Muscle → Aggregation of fascicles
xiii) Epimysium → covering of each muscle

Cardiac muscle:

i) Fibers → Do not run parallel to each other
ii) Fibers → Branch & Anastamose with each other
iii) Nucleus → central, spherical nucleus
iv) Intercalated disc →
Dark stria b/w adjacent cardiac myocyte
Made of Anchoring junction's [Macula & Zonula adherens]
Contain gap junction's [transfer of action potential from one cell to another]
No tight junction's [2017 Nov AIIMS]

Smooth muscles :



i) Smooth muscles → Present in the hollow visceral organs
ii) cells - Spindle shaped
iii) Nucleus → Flat, Centre
iv) No Striations
v) Involuntary & supplied by ANS

Nervous System

Neuron :

Neuron: cell body + Process

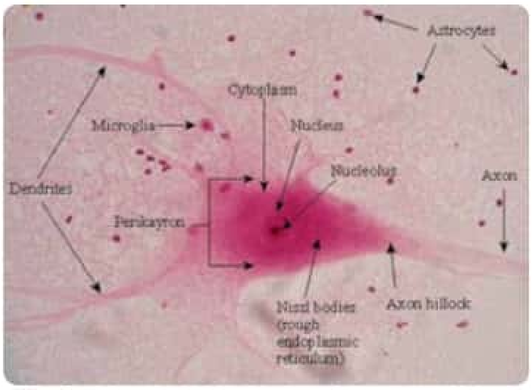
Cell body of neuron:

contain's cytoplasm bound by cell membrane

Nissl granules : Intense staining with basic dyes contain granular cytoplasmic reticulum [active protein synthesis)

Neuro fibers: Thread like substance permeating the cytoplasm

Types: microtubules
micro filaments



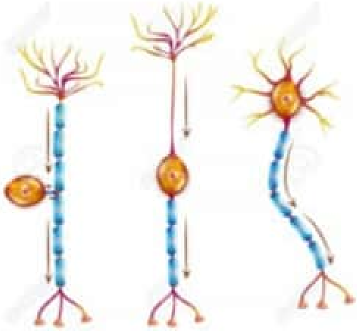
Neurites - Process of the neuron:

Types : Dendrites
Axons

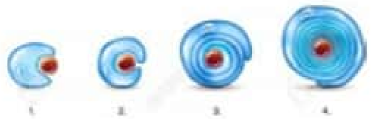
Dendrites	Axons
Short	Long
variable thickness	Uniform thickness
Nissl granules extend into dendrites	no extension of NG into axon Axon hillock: Nissl free zone extending into the cell body for a short distance
carry impulse towards the cell body	carry impulse away from the cell body

Myelin sheath formation for Peripheral nervous System:

CMO - CNS myelin sheath formed by Oligodendrocytes
SPM - Schwann cells - formation of peripheral nervous system Myelin sheath

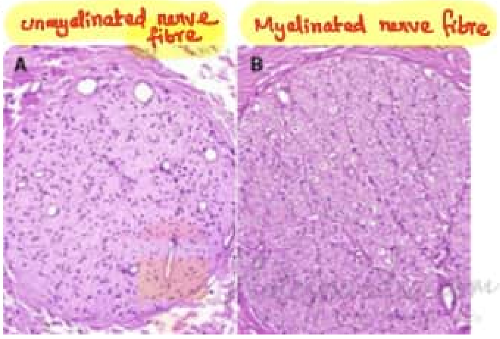


1. Axon invaginates into shwann cell
2. mesaxon : Suspends the axon from the schwann cell
3. mesaxon elongates
   ↓
   loops around to form multiple layers around the axon.
   ↓
4. Lipids deposited in mesoxon
   ↓
   Forms myelin sheath



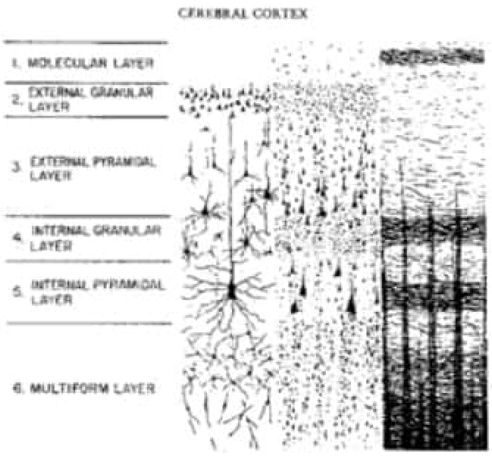
Each axon - Related to numerous schwann cells

Nodes of Ranvir : Gap in the myelin sheath at the junction of 2 schwann cell segments.



Cerebral cortex:

cells in cerebral cortex


CEREBRAL CORTEX
1. MOLECULAR LAYER
2. EXTERNAL GRANULAR LAYER
3. EXTERNAL PYRAMIDAL LAYER
4. INTERNAL GRANULAR LAYER
5. INTERNAL PYRAMIDAL LAYER
6. MULTIFORM LAYER

1. Pyramidal cell	2. Stellate cell
Triangular in shape Apex : origin of large dendrites Base : origin of Axon Numerous processes arise throughout the length - Synaps with other cells	Small multipolar cells aka granular cells

Layers of cerebral cortex: (superficial to deep)

1. molecular layer
   Horizontal fibers + Supporting cells of cajal
2. External granular layer
   Densely packed with granular cells
3. External pyramidal layer
   Small and medium sized Pyramidal cells
4. Internal granular layer
   - Heavily myelinated horizontal fibres - outer band of Baillarger
   - Densely Packed with granular cells
5. Internal pyramidal layer
   Large Pyramidal cells
   Inner band of Baillarger
6. Multiform layer : contain all cells aka pleomorphic layer

Arrangements of layers in cerebral cortex:

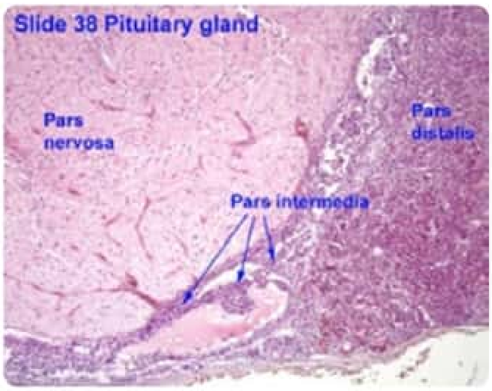
sensory cortex
Granular layer > Pyramidal layer

motor cortex
Pyramidal layer > granular layer

Endocrine System

Pituitary gland:

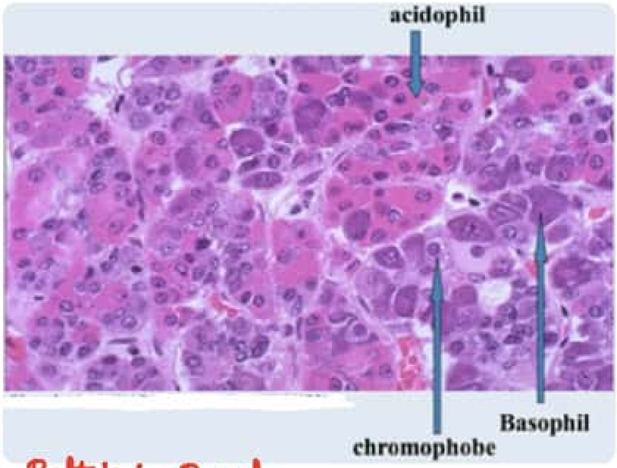
Pars distalis / Pars anterior:
Cords of cells
Sinusoids b/w the cords
Type of cells



Chromphil cells
Bright staining granular in cytoplasm
- Acidophils
- Basophils

Chromophobe cells
Granules not prominent
↓
contain cells similar to chromophil cells

Acidophils	Basophils
Stain with acidic dyes (Eosin)	Stain with basic dyes (Hematoxylin)
1. Somatotrophs - secrete growth hormone	1. corticotrophs
2. mammotrophs secrete - prolactin	2. Thyrotrophs
	3. Gonadotrophs



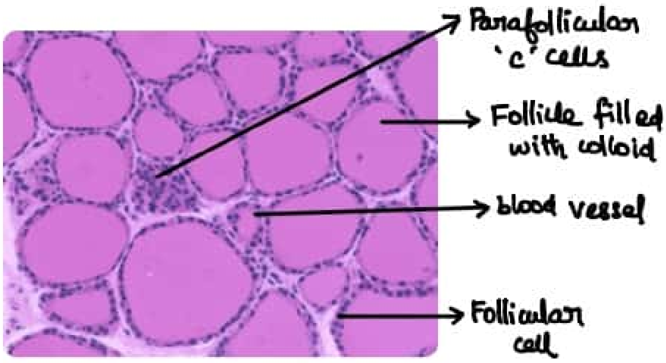
Pars intermedia:

Poorly developed
vesicle filled with colloid - Remnants of Rathke's Pouch
Secrete melanocyte stimulating hormone (MSH)

Pars nervosa:

unmyelinated axons of hypothalamic neurons (supra optic & paraventricular nucleus)
pituicytes - Supporting cells
secrete - vasopressin and oxytocin

Thyroid and parathyroid gland:

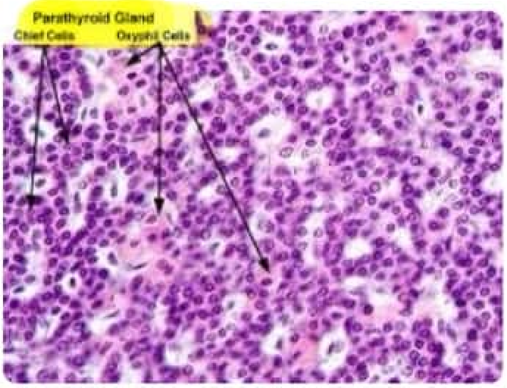


Septum arising from capsule
↓
Divides gland into lobules (aggregation of follicles)

Follicle:
- lined by follicular cells
- Encloses cavity filled with colloid

I Follicular cells:

1. shape :
   active state - cuboidal
   inactive state - Squamous
   Hyperactive state - Columnar
2. contain :
   Apical microvilli
   Supra nuclear golgi bodies
   Rough endoplasmic reticulum



II Parafollicular / 'c' cells :

Polyhedral cells with oval excentric nucleus secrete thyrocalcitonin

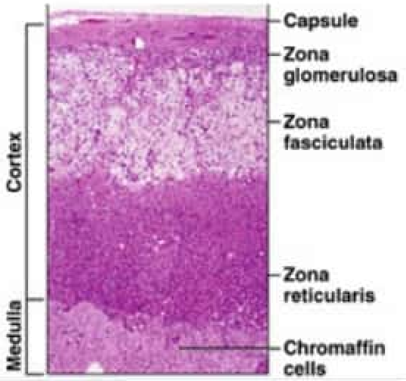
Parathyroid gland:

cells of parathyroid gland

Chief cells	Oxyphil cells
Small and numerous	Large and few in number
Small round cells with vesicular nucleus	stain with eosin
Secrete Parathyroid hormone	∴ Ka eosinophilic cells
	Function not known

Adrenal gland:

Adrenal gland
- Adrenal cortex
  - Zona glomerulosa
  - zona fasciculata
  - Zona reticularis
- Adrenal medulla



Zona glomerulosa	Zona fasciculata	Zona reticularis
Umbrella - shaped cells Form 1/5th of cortex Secrete mineralocorticoids Cells : small, polyhedral cells with basophilic Cytoplasm	Cells from straight columns - 2 cell thick layer Forms 3/5th of cortex Secretes glucocorticoids and Androgens Large, Polyhedral cells with basophilic cytoplasm Rich in lipids demonstrated by special stains	cells arranged as cords → Branches to anastomose → Form reticulum form 1/5th of cortex secretes glucocorticoids & sex hormones Similar to fasciculata less lipid content contain brown pigment

Adrenal medulla:

cortex : medulla - 10 : 1

Chramaffin reaction : yellow pigment in cytoplasm of adrenal medulla cells fixed in Chromium salt solution
∴ cells aka chromaffin cells

cells of medulla - Post ganglionic Sympathetic nerves
↓
Secrete adrenaline and nor-adrenaline

APUD System:

Amine precursor uptake & Decorboxylation System

Endocrine cells in the body → secrete hormones

positive chromaffin reaction

Forms amines / peptides by decarboxylation of precursor's in circulation - act as hormones

Cells in APUD System:

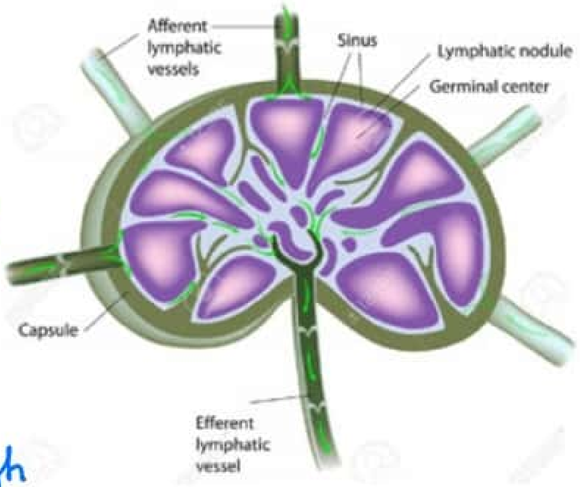
1. Adenohypophysis
2. Neurons in hypothalamus
3. C-cells in thyroid
4. Chief cells in Parathyroid
5. Adrenal medullary cells
6. Glomus cells in carotid body
7. Melanocytes in skin
8. cells of Pineal gland
9. Renin producing cells in kidney.

Histology : Lymphatic System

Primary lymphoid organs :
- produce lymphocytes independent of antigenic stimulus
- eg. thymus, bone marrow

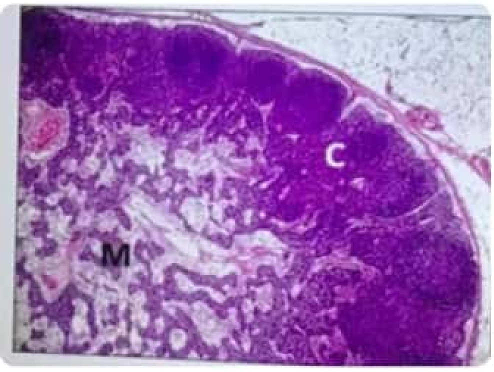
Secondary lymphoid organs :
- produce lymphocytes only in response to an antigenic stimulus
- eg. Spleen, tonsil, lymphnode, MALT

Lymph node :



- Bean - shaped Structure
- Capsule ⊕
- Numerous afferent lymphatics enter the convex surface
- A single efferent lymphatic vessel leaves the hilum

lymph enters via efferent vessels
↓
Forms subscapular Sinus
↓
Numerous cortical radial Sinus pass through lymph node
↓
Reach medulla and forms plexus - medullary sinus
↓
Exits via efferent vessel



Function of lymphnode :
- lymp is filtered by lymphocytes

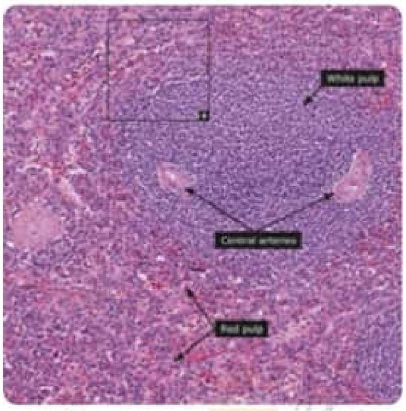
Lymphocytes :
- Arranged as follicles in cortex - lymphatic nodule
- Arranged as cords in medulla

Lymphatic nodule :
- pale germinal layer
- Thick periphery

Spleen :

Numerous trabecular Septae from capsule enter the spleen

Spleenic artery
↓
Branches to spleen (splenic branches)
↓
Enter trabeculae (trabecular arteries)
↓
Arteriole enters inter - trabecular space



White pulp:
- Lymphatic nodule + Eccentrically placed arteriole

straight branches of arteriole [penicillar arteries]
↓
Surrounded by concentric lamellae of fibroblast and macrophage aka Ellipsoid
↓
Distal to ellipsoid, penicillar artery dilates
→ Forms ampulla
↓
Infiltrate splenic tissue

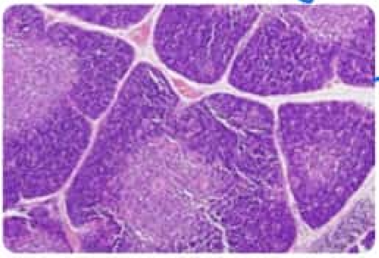
Red pulp: Splenic tissue infiltrated by blood vessel
↓ distal to ampulla
sinusoids + splenic cords of bilroth
Sinusoids lined by banana-shaped endothelial cells - stave cells
cords of bilroth : Reticular collagen + fibroblast + macrophage

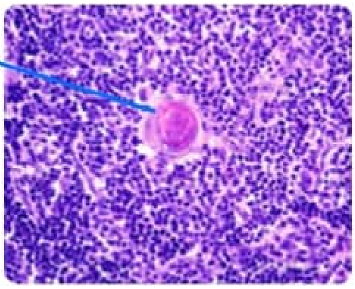
Thymus :

Lobule

- Outer cotex
- Numerous lymphocytes
+
Few reticulocytes

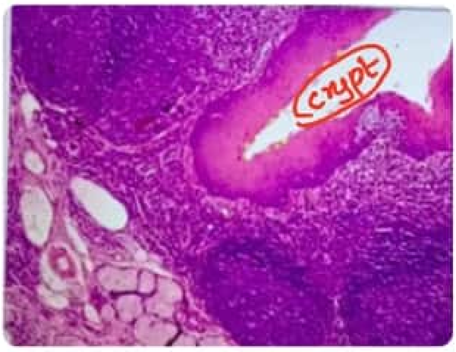
Inner medulla
↑ epithelial reticulocytes
(Hassal's corpuscles)
↓
Concentrically arranged eosinophilic mass
(degenerated epithelium)


Thymus



Tonsil :

only lymphoid organ lined by epithelium [stratified squamous epithelium]
Tonsillar crypt on medial surface
Lymphocytes arranged in nodules
↓
pale germinal centre
Thick periphery



Histology GIT

Overview of GIT histology:

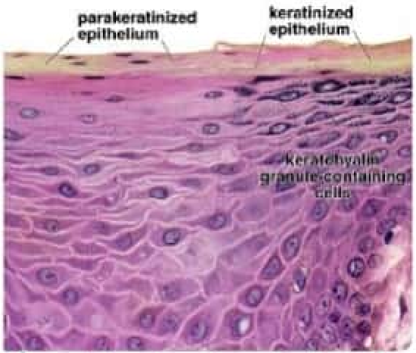
Layers of GIT - 4

Inside
- mucosa - epithelial layer, lamina propria & muscularis interna
  ↳ Lip to esophagus - Stratified squamous non keratinized epithelium
- Submucosa - Strongest layer of GIT, Glands ⊕ in esophagus & duodenum
  - meissner's plexus ⊕

- musculanis externa - 2 layers of muscle [inner circular / outer longitudinal
- serosa/adventitia - Covered by peritoneum = serosa
  Not covered by peritoneum = Adventitia

↓ outside

- Gingiva & hard palate:
  Lined by parakeratinized
  stratified squamous epithelium
  + submucosa


parakeratinized epithelium
keratinized epithelium
keratohyalin granule-containing cells

Nucleus⊕ → Parakeratinized epithelium

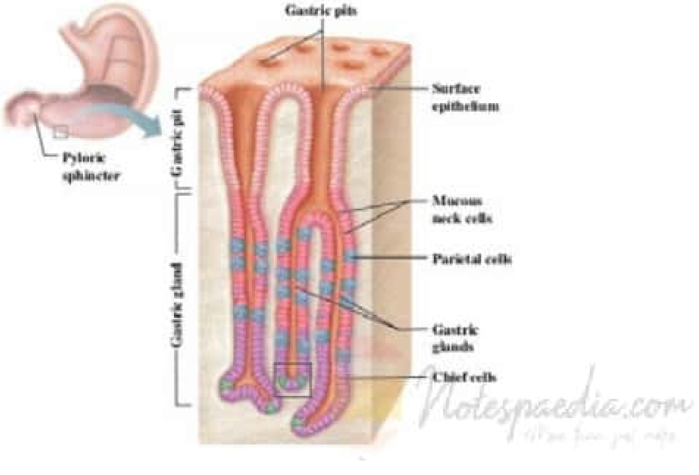
-Epithelial layer:
- Stomach - simple columnar
- Small intestine - Simple columnar with microvilli
- Large intestine — simple columnar (upto pectinate line)
  - From pectinate line to Hiltons line → stratified Squamous non keratinized epithelium
  - Below Hitons line → stratified squamous keratinized epithelium

Lamina propria:
- connective tissue
- Gut associated lymphoid tissue ⊕ (GALT)
- Intestinal glands present
- Stomach - pyloric glands & Cardiac glands

Submucosa:
- Duodenum - Brunner's gland
- Esophagus - Esophageal gland
- meissners plexus present

Musculanis externa:
- Esophagus →
  - upper ⅓rd - skeletal muscle
  - middle ⅓rd - skeletal + smooth muscle
  - lower ⅓rd - smooth muscle
- Auerback plexus present

Stomach:

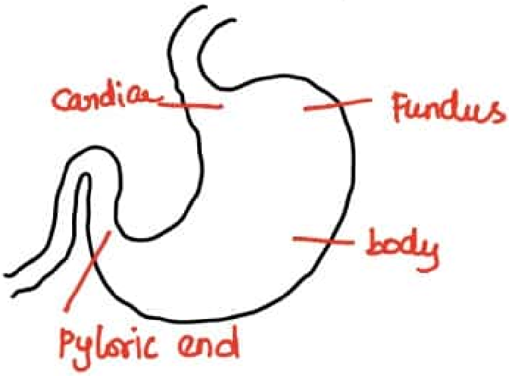


- Inner surface → Gastric pits
- Each pit has 2-3 gastric glands
- Gastric glands has 3 parts
- Neck:
  - Mucous neck cells
- Body: parietal/oxyntic cells
  - ↓
  - Eosinophilic cells with round nucleus
  - Secrete Hcl & intrinsic factor

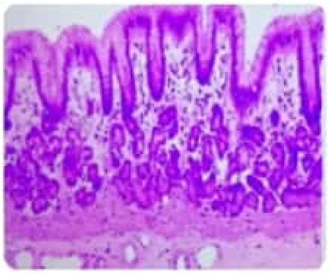
Fundus: chief / peptic cells
↓
- secrete pepsinogen

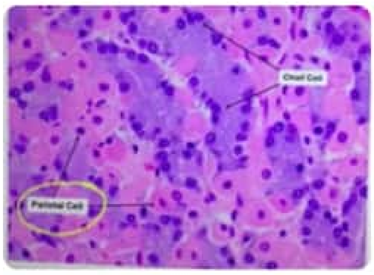
- Goblet cells are absent in stomach

Argentaffin cells
↓
- Neuroendocrine cell
- secrete gastrin



Part of stomach	Glands	Gastric pit
Cardiac	→ cardiac glands mucous glands	→ shallow
Pyloric end	→ pyloric glands mucous cells + Argentaffin cells	→ very deep
Fundus	→ Fundic glands chief cells + argentaffin cells	





Small intestine:

Surface projection - Villi

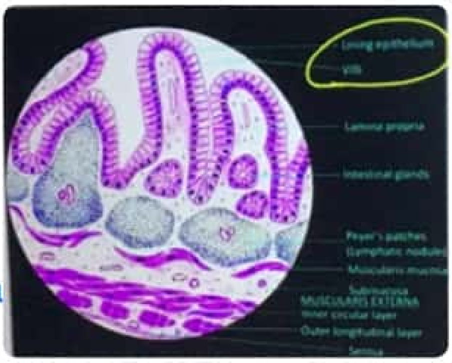
Between the villi
→ Crypts of Lieberkuhn
↓
Glands are seen here

- stem cells - produce enterocytes & Goblet cells

simple columnar epithelium with microvilli

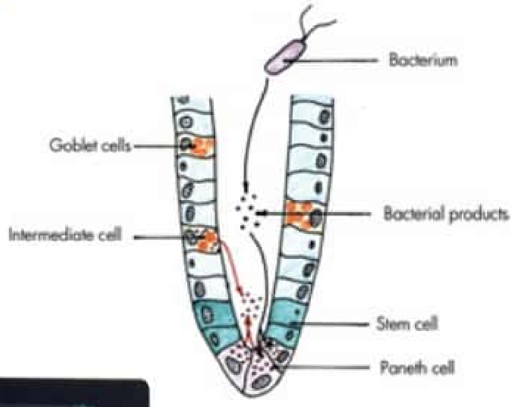
migrate from the base towards the apex

Ileum



- Paneth cells:
  migrate from apex towards the base
  Contain eosinophilic granules in apex
  (Apical esinophilia)
  ↓
  Contains lysosome
  ∴ phagocytic in function

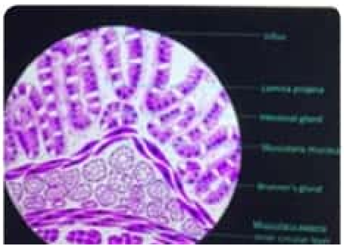
M cells - antigen presenting cell



Duodenum:

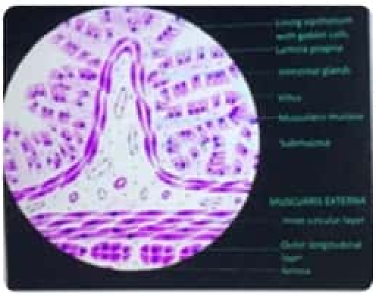
In submucosa → Brunners gland

- proximal part of duodenum
  ↑ Brunners gland
  ↓
  content of stomach is highly acidic
  ∴ additional mucus is required to



Duodenum

Jejunum : No Brunner's gland / peyers patch
Ileum : peyer's patches
Goblet cells - present in small / large intestine



Jejunum

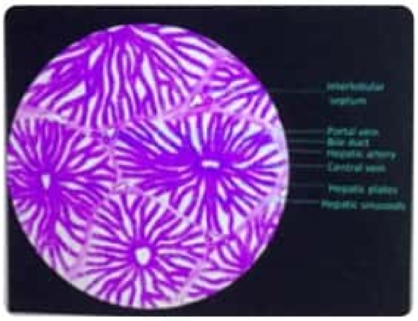
Liver:

Parenchyma → Hepatic lobule (hexagon shape)
↓
Contains anastomosing plate of hepatocyte
(space between them is sinusoids)

At the centre - central vein
At the corner - portal triad
- Portal vein
- hepatic artery
- Bile duct

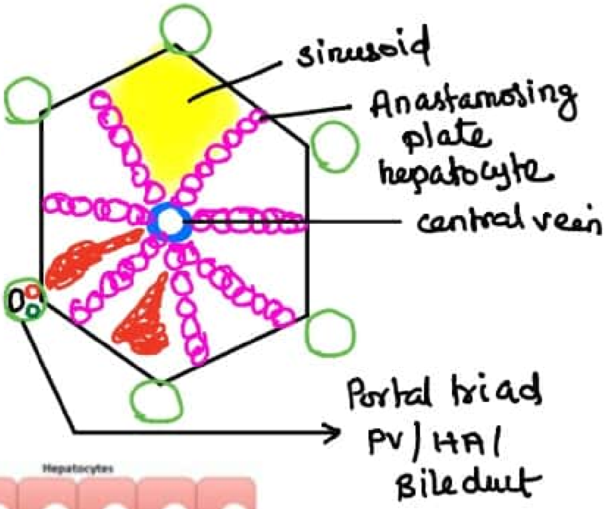
Branches of hepatic artery & portal vein →
flow into sinusoids & drain into central vein

Liver



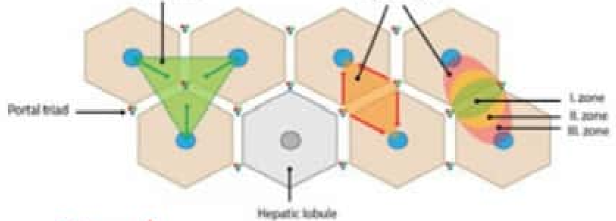
Central vein → hepatic venules → hepatic vein
↓
Inferior venacava

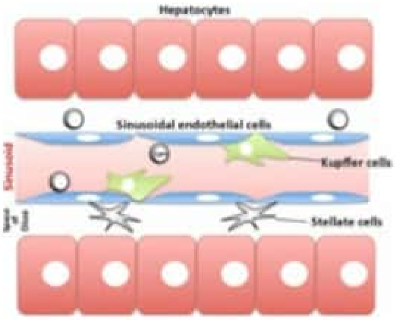
- Sinusoids lined by Endothelial cells
↓ contain
Kupffer cells (macrophage)



Space of disse : perisinusoidal space
↓
- Exchange of metabolities & nutritive substance between liver & blood
- stellate cells

Space of mall : periportal space





Portal lobule

Triangular in shape
Central vein in periphery
Portal triad in centre
Signifies the direction of bile flow

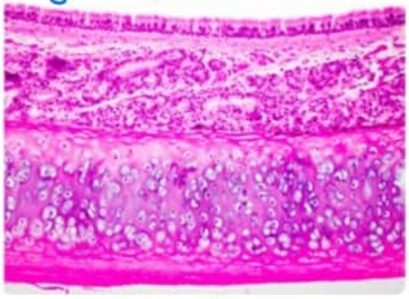
Hepatic lobule

- Diamond shape
- Space between adjacent hepatocytes
Supplied by branches of portal vein & hepatic artery
Zone I = close to portal canal (highly vascular)
Zone II
Zone III - prone to hypoxic injury

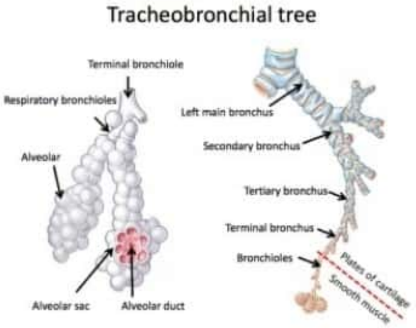
Histology : Respiratory System

Trachea and bronchus - Histology:

Trachea and bronchus - have common histological features



Tracheobranchial tree:



Three layers

Mucosa
- Epithelium - pseudo stratified ciliated columnar epithelium
- Goblet cells
- clara cells - Function like Type II pneumocytes
- Basal cells - Stem cells (mitotic)
- Brush cells - Function not known
- kulchitsky cells - Neuroendocrine cell

Submucosa

Submucous glands

Cartilage layer

Chondrocytes in groups
+
matrix - shiny
↓
Hyaline cartilage

Bronchioles and alveoli - histology:

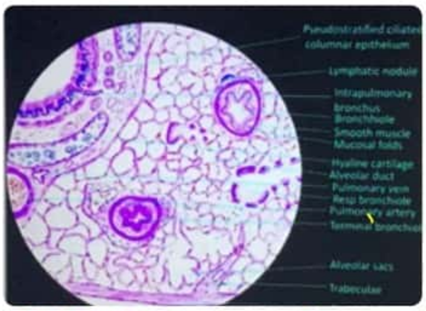
Bronchioles:

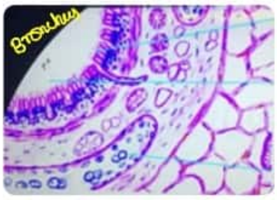
Epithelium - Simple columnar / ciliated Simple columnar

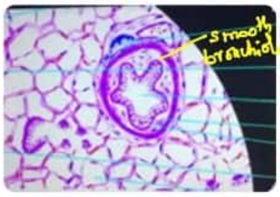
Goblet cells absent

Submucosal glands absent

Cartilage is replaced by smooth muscles







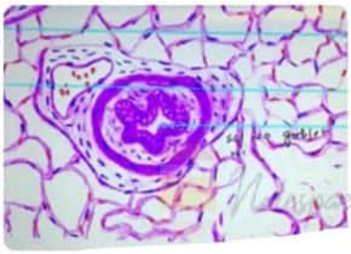
Terminal and respiratory bronchioles:

Epithelium - Simple cuboidal
↓
Towards alevoli - Becomes low cuboidal

Alveoli:

Epithelium - Squamous epithelium

Lined by - Type I pneumocytes - occupies 95%
Type II pneumocytes - occupies 5% - large cuboidal cell
Secrete surfactant



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